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The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Contents

	PAGE
Keeping Secrets...	127
Skin	127
Correspondence	128
Patent Specifications Accepted	128
New Companies	128
Catalogue Received	128
Random Shots	128
The Meaning of the Transverse Test of Cast Iron to the Designing Engineer	129
Fifth International Foundry Congress	132
Roll Foundry at Gateshead...	133
Foundry Facings	134
Vitreous Enamellers First Annual Congress ...	134
Foundry Cost	135
Soft Cast Iron	137
Behaviour of Manganese, Silicon and Carbon in Steel Manufacture	138
This Week's News in Brief	140
Trade Talk	140
Personal	140
Obituary	140
Contracts Open	140
Raw Material Markets	142
Company Reports	142

Keeping Secrets

The capacity of the British people to keep secrets is rather pleasant to record. Two instances have recently been noted. A famous brewing firm decided to transfer some of its activities from Ireland to London. The change was of decided interest to many people and affected stock prices, yet for a long period, during which hundreds of people must have known, nothing was disclosed until the official announcement was made. Again, the nature of the engines fitted to the "534" is a matter of great interest to marine and other engineers, and to our foreign rivals. Many people have been in a position to know, and yet the Press and public have been ignorant until the recent disclosure was made officially. A committee of marine engineers settled the question. Two well known in foundry circles, Sir Charles Parsons and Mr. Andrew Laing, did not live to see them completed. The ship is to have high-pressure high-temperature turbine engines with water-tube boilers and a single-reduction geared turbine. The motor ship has yet to penetrate the highest circles. On grounds of reliability, silence in running, stability, cheapness of installation and low fuel-consumption figures the turbine was chosen. Passages for her maiden voyage in 1936 are already being booked. A Member of Parliament once complained that all the things he did not want could reach him under a halfpenny stamp, whereas the things he did want had to be franked to three times the amount. So much of what we hear we could well forego for that which we would really like to hear and do not.

Two other items of the week's news are not secret, and have a bearing on each other, both aiming at the reform of industry. The Trades Union Congress has had a plan put before it for socialising the iron and steel industry as a public corporation, with a separate board for each branch. The report must owe a great deal to the plans already published for reorganising the industry, and the reservations and general vagueness of the proposals preclude serious criticism. Then the League of Industry, through a mixed committee of employers and employed, has proposed plans for increasing employment. The shorter working week as a solution is strenuously opposed. The increased cost of production could not be recovered in prices, and hence unemployment would be increased. The Committee also opposes compulsory retirement at 65 or 60, and also the eviction of women from industry. The raising of the school-leaving age to 15 is recommended, as is Government encouragement of housing and slum clearance, and financial aid for completing the "534." They deny that machine production increases unemployment and assert that it creates employment in the long run. All of which is eminently sensible and satisfactory.

Skin

Any foundry executive worth his salt takes a considerable pride in the surface of the castings made under his supervision, yet we wonder how many realise the profound effect that skin finish has on the mechanical strength of the member of a unit. "Surface finish" is well worth while for its aesthetic value, on account of the influence it has on those charged with the maintenance of a plant. We remember during the war inspecting some imported locomotives in France, and commenting upon the poor finish they displayed. Sand was still adhering to the corners of bracket castings, whilst the edges of plates which had been parted off by oxy-acetylene cutting were still rough. We made these observations to an American sapper officer, who retorted that where "finish" was necessary finish had been given, and efforts beyond this were time-wasting.

Quite recently we inspected a set of the largest roller bearings ever made, to be used in conjunction with a rolling mill. In this case the trade mark and other indications had been etched upon the highly-polished surface, as even the action of stamping indications was deemed liable to be a potential source of cracking. Where steel castings have been welded it has been shown that it is well worth while to do more than scratch-brush the weld, but rather should they be ground and polished, as this results in materially enhanced mechanical strength. In Harley Street there is a school of thought that relates cancer to skin diseases; so to under-repeated impact, or vibrational stresses, a poor skin can be the starting point of cracks resulting in ultimate rupture of the member so stressed. The medical profession has created skin hospitals in which fundamental researches are prosecuted. The metallurgical profession would not be ill-advised to emulate their medical colleagues. At the moment, it is the light-castings industry and those persons making small repetition work which produce the finest skin on their castings. Their problems are somewhat easier owing to mass effect, but there is still room for improvement in medium and heavy work, both in steel and cast iron. Added interest would be taken in the work of sands carried out by the British Cast Iron Research Association and private investigators if experiments were carried out relating surface to mechanical strength.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Chromium in Malleable Iron

To the Editor of The Foundry Trade Journal.

Sir,—In the issue of The Foundry Trade Journal of August 23, I note on page 114 in column 2 a note having reference to the addition of chromium to malleable iron. In this it says:—"Chromium up to 0.50 per cent. is now being used commercially in malleable castings. . . . Chromium increases the tensile strength and has no adverse effect on the annealing property."

In case any of your readers may be tempted to try out chromium additions of this order to malleable iron I think it might be helpful to issue a warning. Quite definitely chromium does increase the tensile strength of malleable iron. I have at the moment in front of me some figures showing that the addition of between 0.25 and 0.5 per cent. of chromium to malleable iron results in an increase of tensile strength up to 30 tons per sq. in. These are results obtained from experiments which I personally carried out; but equally definitely chromium *does* have an *adverse* effect on the annealing properties, particularly if no steps have been taken to see that the composition of the basic metal has been adjusted to take care of the chromium content.

As you are aware, considerable work has been done in connection with chromium additions to malleable iron in U.S.A., but I might mention that also a considerable amount of scrap castings resulted through some manufacturers "rushing in" to add chromium to their malleable without giving the problem due consideration. The addition of chromium under ordinary conditions materially reduces the elongation, in fact to such an extent that in some cases it is doubtful whether the metal can still really carry the designation "malleable" iron.

I wish to make it quite clear that I am not depreciating any experiments or work that has been carried out in this direction, but feel a note of warning should be issued to go warily in any efforts to produce an improved malleable iron, particularly when these efforts may involve the use of carbide forming constituents.

Incidentally, as your readers may be aware, the additions of chromium to malleable iron gives a product which is very useful in some directions where malleability is not essential but resistance to wear is.—Yours, etc.,

H. H. Shepherd,

(Chief Metallurgist, Crane, Limited).

Irish Free State trade imports for the month of June show imports of iron and steel and manufactures thereof for the period totalling £211,853, as against £122,903 for the corresponding month last year, making a total of £1,189,481 for the six months January to June, as against £707,714 for the first half-year of 1933. Railway material imported increased from 148 tons to 770 tons, cast pipes and fittings from 4,367 cwts. to 4,866 cwts., other tubes, pipes and fittings from 19,311 cwts. to 32,208 cwts., wire manufactures from 1,135 cwts. to 1,129 cwts., bolts, nuts and screws from 3,095 cwts. to 4,258 cwts., stoves, grates, ranges and parts from 5,903 cwts. to 7,114 cwts., and nails, tacks, rivets and washers from 6,924 cwts. to 7,247 cwts. Wire imports fell from 9,399 cwts. to 8,112 cwts., but other manufactures of iron and steel increased from a total value of £26,652 to £72,549. Imports of machinery and electrical goods and apparatus reached £227,351, as against £181,063, making a total of £1,128,735 for the six months period as against £927,510. Boilers and boiler-house plant totalled a value of £17,408, agricultural machinery £6,630, bread and biscuit machinery £3,006, boot- and shoe-making machinery £2,760, dairy £4,416, electrical £27,717, prime movers, not electrical, £4,587, pumps £2,647, sewing £6,106, textile £5,668 and other descriptions £83,969.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

409,310. Freeland, E. M. Treatment of silicon steels and the improved silicon steels.

409,355. Kroll, Dr. W. Process for improving alloys containing iron, aluminium and nickel.

409,380. American Rolling Mill Company. Iron alloys.

409,411. Krupp Akt.-Ges., F. Steel alloys.

409,525. Klopstock, H. Joining and coating of cast iron and the filling of blow-holes, scores, cracks and fissures therein.

409,579. Schichau Ges., F. Cylinder linings and pistons for coal-dust and high-speed Diesel engines.

409,800. Lysaght Protected Steel Company, Limited, and Keay, H. W. Protection or covering of metal and means therefor.

409,560. Davey, G. W. Furnace-wall construction.

410,155. Dewrance, Sir J. Machines for making sand cores and moulds.

410,691. Primrose, J. M. Foundry moulding machines.

410,400. Nitralloy, Limited. Process for hardening corrosion-resisting iron and steel alloys by nitrogenisation.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Victoria Brassworks (Burnley), Limited.—Capital £600. Director: T. Lewis, 6, Mona Street, Preston.

Bilston Castings, Limited, Highfields Road, Bilston, Staffs.—Capital £1,000. Directors: C. T. Hipkins, H. C. Sargent and G. Buchanan.

Walthamstow Iron & Steel Company, Limited, Bank Chambers, 45, Ludgate Hill, London, E.C.4.—Capital £100. Dealers in scrap iron and steel.

G. Rollinson & Company, Limited, Parsonage Chambers, 3, The Parsonage, Manchester.—Capital £5,000. Iron, steel, metal and machinery merchants. Directors: G. Rollinson, L. F. W. S. Smith and F. H. Binns.

Catalogue Received

Gate Elimination. Enclosed with the July issue of "Crossley Chronicles" was Publication No. 1060*b*, which describes and illustrates a device to avoid gates. For this purpose a gap 8 ft. wide is made in the fence close to the gate and a pit is prepared on the more convenient side of the 6 ft. wide by 4 ft. deep. Over this run two parallel steel ladders, which, laid horizontally, from the pathway for the car wheels. Animals and ground game refuse to tackle a ladder-like exit for the crime of straying. Motorists are freed from the trouble of getting out to open gates, whilst there is no fear of ramblers leaving open field and park gates. The contraption is marketed very cheaply by Messrs. Crossley Brothers, Limited, Openshaw, Manchester.

(Continued from next column.)

marching boldly up the long stretch of beach, bellowing threats of what would happen to the man who had hired him a costume five sizes too small. Then the beach inspector, a nasty, officious little man, saw him.

* * *

We spent the rest of the afternoon explaining to the beach inspector that Bill was neither a sun-bather nor a nudist, and convincing an unbelieving policeman that when Bill hit the beach inspector he really meant no harm.

Marksman.

Random Shots

Last week "Marksman" joined the staff of a local foundry on their annual outing. It was not a success. To begin with, there had been much bother in choosing a suitable seaside town. Bill, a massive moulder of herculean build, revealed very definite views on the matter, and did much successful lobbying on the basis that might is right. Bill strongly objected to Broadstairs, Margate and Bognor. With some reason he argued that those who worked in and among sand all the year round wanted to get away from the blankety-blank stuff on their holiday. Eastbourne, as the town which cherishes Miss Nellie Snooker's Gayway Foundry, was discussed, but Bill's mother-in-law lived there. So we could not go to Eastbourne. It soon became evident that Bill was to be the deciding factor in the outing. Even the foundry manager seemed afraid of him. When a little patternmaker, who had argued in favour of Eastbourne, threatened to give Bill in charge for assault and battery, the manager took Bill's side. So we all went to Southgate-on-Sea. There were no sand, no relations, and Bill knew the manager of the "Crown and Anchor."

* * *

We were given a wonderful reception at Southgate. The cheering crowds were surprising, but this, we thought, was the friendly holiday spirit that people talk about. Girls were actually throwing flowers. We waved back, and Bill threw a sandwich at a blonde which hit an old gentleman in a bath-chair. Everything was as cheery and bright as you could wish. Quite Continental, as the foreman described it. But when we saw the Mayor and Corporation in full regalia some of us began to think that there had been a mistake. We were right. There had been a misunderstanding. It was all very awkward at first, but the only actual unpleasantness was when the Mayor called Bill a foul-mouthed blackguard and said that he was intoxicated. In the end we got things straightened out. It turned out that before we started the foreman had rung up the manager of the "Chatham Arms" to tell him the number of us who wanted lunch. The line was bad and the conversation indistinct. When the foreman said that a party was arriving at mid-day, the manager asked the name of the party. The foreman, a real old cockney, could not hear, and shouted "Carn' 'ear you!" At that the manager said he was honoured, banged down the receiver, and announced to the Saloon Bar that Carnera was coming for lunch. News spreads, particularly at the seaside. So it was that the Mayor and Corporation, already assembled for the Annual Carnival, were there to give Carnera a rousing welcome. The Mayor thought that Bill must be the famous giant, and advanced with outstretched hand. "Mr. Carnera, I presume?" It was just after that he called Bill a foul-mouthed blackguard.

* * *

The lunch was good. The weather was superb. Most of us went off for a bathe. If only there had been a cold wind and a steady fall of rain! By not having that bathe we should have been saved much trouble and unpleasantness. Bill had to hire a bathing costume. None would fit him, but they gave him the biggest they had. It was much too small. The tide was a long way out, and most of us were a little short-tempered when we reached the sea. But the trouble, the real trouble, came later, from Bill, when his costume, groaning under a terrific strain—split!

* * *

If Bill had only been sensible about it, all might have been well, but he was not. Disdaining all our offers of help, he insisted on

(Continued in previous column.)

The Meaning of the Transverse Test of Cast Iron to the Designing Engineer*

By Dr. James T. MacKenzie

The transverse test long has been applied to cast iron but usually has been considered merely a foundry test of the quality of the iron in the ladle. As such, it has been accepted grudgingly by the inspector, and practically ignored by the designer who has used the lowest tensile strength shown in the particular handbook which he consulted. The strongest argument against the transverse test in favour of the tensile test is that the latter gives values to which the engineers are accustomed and which they can apply directly.

Simplicity of conversion of transverse test results to unit values applicable to design never has been taught the foundryman or the engineer in America. In Germany, *bending strength* has supplanted completely *breaking load* and the prising amount of information on toughness, stiffness, damping capacity, machinability, and the relation of plastic to elastic deformation.

Cast iron is treated best from the structural standpoint as a mechanical aggregate of steel and graphite, the steel forming a continuous matrix around the particles of graphite. It is mainly the amount and distribution of the graphite which determines the properties of a particular cast iron. A cross-section of a heavy casting may exhibit a continuous variation from fine to coarse flakes, from fine specks to thick lenses, from delicate dendrites to heavy rosettes, or from 0.0 to 3.5 per cent. carbon. This intermixture of graphite and steel confers on cast iron many of its peculiar properties, such as its machinability, wear resistance, freedom from

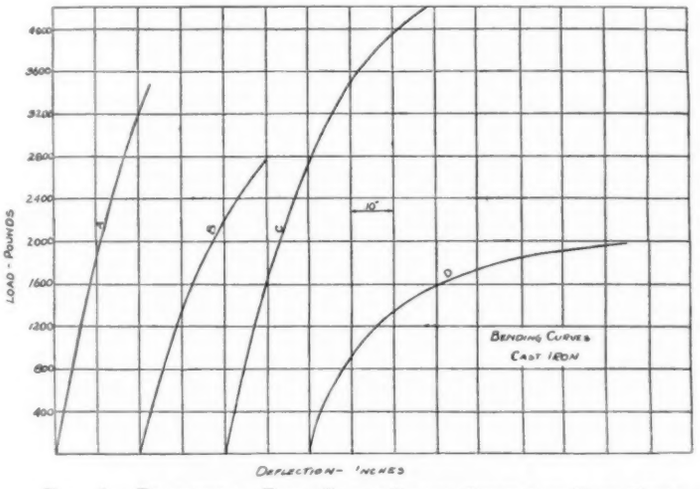

Fig. 1.—Transverse Test Stress-Strain Curves of Four Types of Cast Irons.

British Cast Iron Research Association has encouraged actively the use of modulus of rupture instead of breaking load for some years. Few direct applications of deflection have been made. German literature still reports deflection, although the recent work of Thum and Ude and Meyersberg may lead to the adoption of a rational expression involving this property.

Estimates Surface Condition

Transverse test for strength is made easily, although accurate deflection measurements require considerable care as shown in the joint A.F.A. and A.S.T.M. 1933 "Symposium of Testing of Cast Iron." This test is made usually on the "as-cast" surface, which gives a direct estimate of the surface condition of the casting, something not obtained often in the tensile test which is made usually on a machined specimen. If the casting is to be machined, pickled, or tumbled, the transverse test-bar may be treated in the same manner, thus preserving the essential surface resemblance to the casting.

The structure of cast iron is chiefly the result of composition and cooling rate. Cooling rate is the net result of thickness of section and character of mould. It is a great advantage to be able to test a specimen with a surface formed under the same conditions as that of the casting. Where an accurate plot is made of the load-deflection curve, the transverse test gives a surgalling and seizing, damping capacity and the complex relation of stress to strain.

Thum and Ude[1] first proved that the stress-strain relationship of cast iron could be simulated in steel by making slits, holes and notches in steel test-pieces. When cast iron is in tension, the graphite acts as an empty space but functions as a solid filler in compression. Four typical transverse test, stress-strain curves are shown in Fig. 1. Those irons are taken from the 1933 report of Sub-Committee XV of A.S.T.M. Committee A-3. Curve *A* shows a stiff, strong cast iron of 1.00 per cent. combined carbon and 1.50 per cent. graphite. Curve *B* shows an "ordinary" cast iron of 0.68 per cent. combined carbon and 2.44 per cent. graphite. Curve *C* shows a cast iron of 0.85 per cent. combined carbon and 1.94 per cent. graphite, while curve *D* shows an extremely soft cast iron containing 16 per cent. nickel, 2 per cent. chromium and 6 per cent. copper, with 0.76 per cent. combined carbon and 2.32 per cent. graphite in an austenitic matrix.

Bending Curves Contain no Straight Lines

With such bending curves as shown in Fig. 1, it is not surprising that cast iron does not give the same values for tensile strength, compression strength or bending strength (modulus of rupture). It is also evident that Young's modulus of elasticity must be an empirical figure for cast iron, since no part of any of these curves is a straight line.

These relations for an engineering cast iron of 50 years ago of 17,000 lbs. per sq. in. tensile strength were worked out by Bach,[2] who determined the stress-strain relationship in tension, compression and transverse. He also calculated the ratio of transverse to tensile from the graphs of compression and tensile values shown in

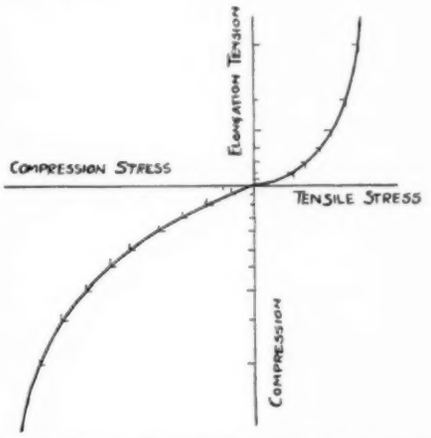

Fig. 2.—Stress-Strain Relationship, both in Tension and Compression (Bach).

Fig. 2, and found that the neutral axis in bending was displaced 8 per cent. towards the compression side in bending. This assumption checked the bending moment in transverse within 3½ per cent., which is surprisingly close since the tensile test was made on a 20-mm. bar

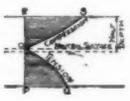

Fig. 3.—In Bending, the Neutral Axis is Displaced from the Centroid in a Symmetrical Section nearer the Compression Edge.

machined from the 80-mm. compression specimen. Perhaps the clearest statement of the problem in English is given by Morley.[3] He says:—"... for cast iron, ... the strain in tension is much greater, and deviates much more from

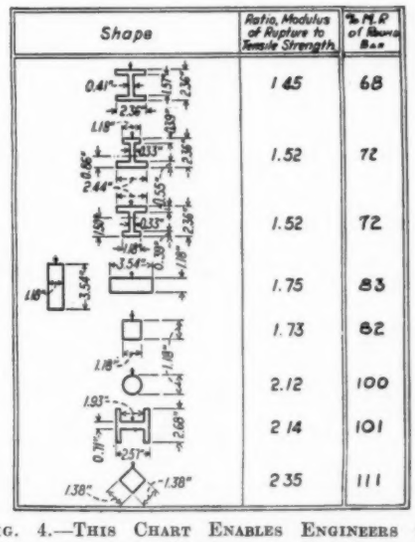

Fig. 4.—This Chart Enables Engineers to Calculate the Modulus of Rupture for many Sections.

proportionality to stress than in compression. The distribution of stress on a symmetrical section will, therefore, be somewhat as in Fig. 3; the neutral surface will no longer pass through the centroid of the area of cross-section, but will be nearer the compression edge, which, yielding less than the tension edge, will have a greater

* Paper presented before Joint Meeting of Birmingham Alabama Section of the A.S.M.E. and District Members of A.F.A., subsequently presented before Foundry Practice Meeting of A.S.M.E., December, 1933, in New York. The Author is Chief Metallurgist with the American Cast Iron Pipe Company.

1 Die Giesserei," April, 1929.

2 Elastizitat und Festigkeit, Neunte Auflage, p. 298.

3 Strength of Materials, 6th Edition, p. 148.

intensity of stress. If the beam is of constant breadth, *i.e.*, of rectangular cross-section, the actual surface will move from half depth in such a way that the areas OPQ and ORS remain equal, for the total tension and total thrust are of equal magnitude and form a couple.

Modulus of Rupture.—When a bar of metal is tested by bending until rupture takes place, the intensities of stress at the outer layers at rupture are not those given by the formula $f = \frac{My}{I}$ since the condition of elasticity there assumed has ceased to hold good. Nevertheless, the quantity $\frac{My}{I}$ or $\frac{M}{Z}$ where M is the bending moment at rupture, is very often used as a guide to the quality of cast iron. It is evidently not a true intensity of stress, and is called the transverse modulus of rupture—in cast iron the modulus is much higher than the ultimate tenacity in a tensile test, for two reasons. Firstly, because the tensile strain at comparatively low stress at one edge allows a distribution

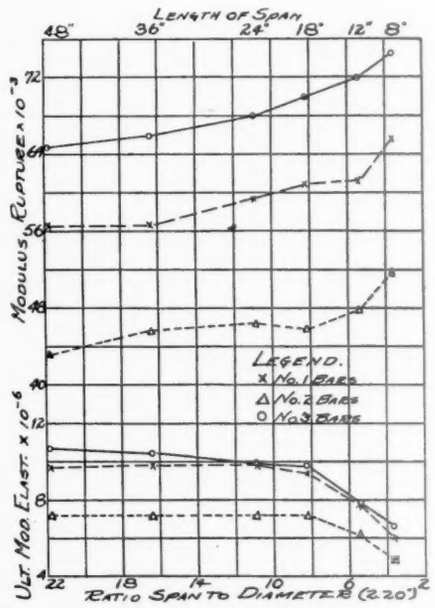
LENGTH OF SPAN
48" 36" 24" 18" 12" 8"
MODULUS RUPTURE x 10⁻³
ULT. MOD. ELAST. x 10⁻⁶
LEGEND.
× No. 1 BARS
△ No. 2 BARS
○ No. 3 BARS
RATIO SPAN TO DIAMETER (2.20")²

FIG. 5.—SHOWING THE RELATION BETWEEN SPAN AND TRANSVERSE MODULI OF RUPTURE AND MODULI OF ELASTICITY.

of stress similar to that sketched in Fig. 3, thereby using the high compressive strength of cast iron to advantage. And secondly, because the inner layers of material under the distribution of stress previous to rupture carry a higher intensity of stress than is contemplated by the formula $\frac{f_1 I}{y_1}$ or $\frac{PI}{y}$ or $1/6fbd^2$ (for a rectangular beam) for the moment or resistance, thereby increasing the resistance."

Outer Fibres are Stronger

Prof. Morley does not mention the greater strength of the outer fibres stressed in the transverse test than that of the section usually tested in tension. However, the empirical nature of the transverse results is not a bar to their use in design, since the effects of most of the variables have been determined experimentally. It is just as logical to apply the modulus of rupture to the design of a scale beam as it is to apply the tensile strength to the design of a compressor cylinder.

Modulus of rupture is calculated from the well-known beam formulæ by solving for fibre stress. Modulus of elasticity is determined by solving for E, Young's Modulus, in the same formulæ. The most common case is that of a beam with free ends and a single, centrally-applied load. The formulæ are then:—

$$f = \frac{Pl}{4S} \text{ and } E = \frac{Pl^3}{48DI}$$

where f is the fibre stress or modulus of rupture; P, the load in pounds; l, the span in inches; S, the section modulus; E, the modulus elasticity; D, the deflection in inches; and I, the moment of inertia.

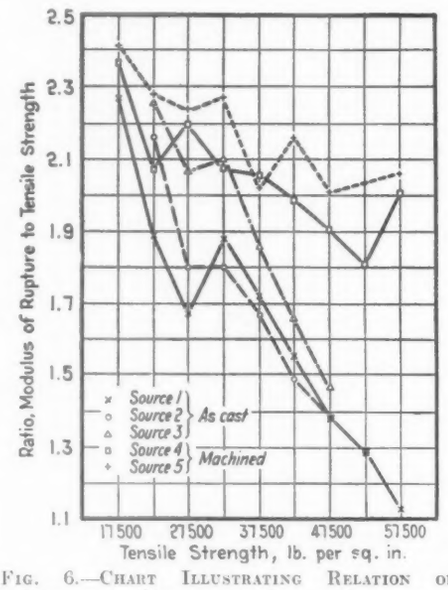

FIG. 6.—CHART ILLUSTRATING RELATION OF MODULUS OF RUPTURE TO TENSILE STRENGTH.

Formulæ become Simple

For any standard bar, $\frac{l}{4S}$ and $\frac{l^3}{48I}$ are constants and the calculations become extremely simple. For the commonly used A.S.T.M. standard bars, the formulæ become:—

Bar section.	Span in in.	Modulus of rupture	Modulus of elasticity
0.875 in. round ..	12	45.61 P	1,251 P/D
1.20 in. round ..	12	17.69 P	354 P/D
1.20 in. round ..	18	26.53 P	1,194 P/D
1.25 in. round ..	12	15.65 P	300 P/D
2.00 in. round ..	24	7.64 P	367 P/D
1.00 × 2.00 in. rect.	24	18.00 P	1,728 P/D

The bars must be corrected to standard size before these simple formulæ can be applied with accuracy.

As will be apparent from the bending curves shown in Fig. 1, the modulus of elasticity will vary from point to point on the curve. When calculated from breaking load and deflection, E is a relative index of the stiffness. *When calculated from the actual deflection at stresses comparable to those contemplated in the design, the resultant modulus may be used confidently for calculating the bend of the member.* Modulus of rupture varies with the shape of the specimen, as is shown in Fig. 4 taken from Bach. If the test results are from a round bar, and the design calls for a rectangular or square section, the modulus of rupture from the test should be multiplied by 0.83 in calculating the strength of the member, etc. This ratio has been checked by the author with the following statistical results:—

$$\text{Modulus of Rupture} \frac{\text{rect. } 1.00 \times 2.00 \text{ in. by 24 in. span}}{\text{round, } 1.20 \text{ in. dia.} \times 18 \text{ in. span}}$$

39 sets of bars (3 bars in each set) average,	$\overline{X}$	= 0.84
Root mean square deviation	σ	=00.065
Minimum ratio		= 0.68
Maximum ratio		= 1.02

Modulus of rupture and modulus of elasticity both vary with the span, as is shown in Fig. 5. The differences are not important until the span becomes so short that shearing stresses begin to play an important part in the bending test. Variation of the modulus of rupture with tensile strength is shown[4] in Fig. 6 taken from the following:—

1. Data on plain cast iron published in the American technical literature of the past 10 years. 2. MacKenzie—A.S.T.M., 1931 (tensile values added by the author). 3. Thum and Ude—Die Giesserei, April, 1929. 4. 1.20 in. dia. transverse (machined) 0.8 in. tensile. 5. 0.5 × 5 in. transverse (machined) 0.5 in. tensile (Report of Sub-Com. XV of Com. A-3, A.S.T.M., 1933).

The striking difference in ratio of the machined and unmachined bars is a powerful illustration of the effect of surface conditions on the bar used ior the transverse test and shows the especial importance of this factor in the present high-strength irons.

Bars show a Difference in Properties

The general relation between modulus of rupture, compression strength, tensile strength, shear strength and endurance limit, which is

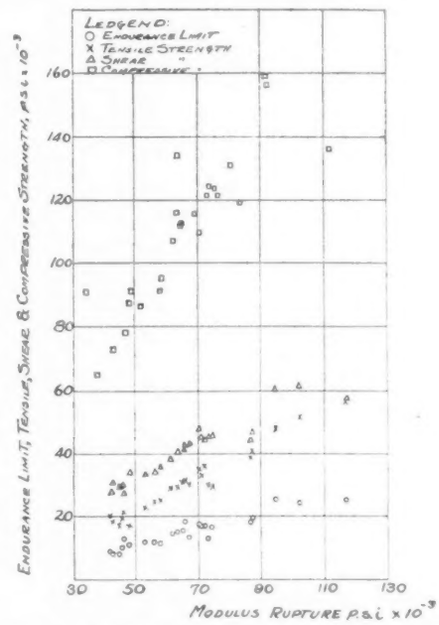
LEGEND:
○ ENDURANCE LIMIT
× TENSILE STRENGTH
△ SHEAR "
□ COMPRESSIVE "
ENDURANCE LIMIT, TENSILE, SHEAR & COMPRESSIVE STRENGTH, P.S.I. x 10⁻³
MODULUS RUPTURE P.S.I. x 10⁻³

FIG. 7.—GENERAL RELATION BETWEEN MODULUS OF RUPTURE, COMPRESSION STRENGTH, TENSILE STRENGTH, SHEAR STRENGTH AND ENDURANCE LIMIT SHOWN.

usually a transverse test, is shown in Fig. 7. This chart shows that the modulus of rupture is as reliable an index of strength as any of the others when all are made on the same specimen. All specimens used in these tests were machined to size from 1.4-in. diameter bars. Tensile and shear test-bars were 0.5-in. diameter, and endurance limit test-bars were 0.33-in. diameter. Data obtained in these three tests were plotted against transverse bars of 0.5-in. diameter, while data of compression test-bars of 1.20-in. diameter were plotted against data of transverse bars of 1.20-in. diameter.

While the accuracy of deflection measurements ordinarily reported is not of a very high order, it requires only a little care to secure values sufficiently good for ordinary engineering use in determining deflections of beams, arches, etc. Tensile and compression moduli determinations require equipment of a higher degree of accuracy than that possessed by most foundries. If load-deflection curves are plotted, the modulus of elasticity at any required stress can be calculated easily by the formulas previously given. That figure in the useful range of stress, up to

[4] The full set of statistics on which this figure is based will be found in the joint Symposium on Cast Iron, A.F.A. and A.S.T.M., 1933.

25 per cent. of the breaking load, is close to the modulus of elasticity as determined in tension or compression. That is shown by the statistics, shown in Table I, taken from the A.S.T.M. Committee report on impact tests of cast iron, previously cited.

TABLE I.—*Ratio Modulus of Elasticity at ¼ Load in Compression and Tension to Transverse.*

	Compression.	Tensile.
Average ratio	0.87	1.05
Standard (Root mean square) deviation	0.10	0.12
Minimum ratio	0.69	0.82
Maximum ratio	1.06	1.30

Modulus of elasticity in torsion and shear commonly is taken as 40 per cent. of the value

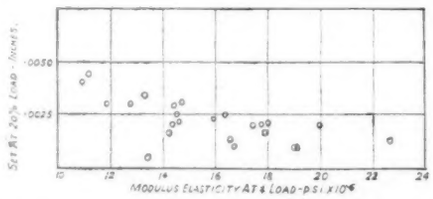

FIG. 8.—SET AS DETERMINED ON 1.20 × 18 IN. TRANSVERSE TEST BARS AT 20 PER CENT. LOAD.

in tension and may be assumed to be in the same ratio to the transverse value. In addition to its direct application in bending calculations, the curvature and slope of the bending curve are related directly to three important engineering properties, damping capacity, permanent set or plastic deformation, and machinability. Damping capacity is the ability of a metal to absorb or dissipate vibration. That property is of considerable interest in machine tools, printing presses, etc. It is clearly related to modulus of elasticity through the formula for acoustic resistivity. $u = \sqrt{EP}$, where u is acoustic resistivity, E modulus of elasticity, and P the specific gravity. The soft cast irons, which give high ratios of deflection to load (low E) show the highest damping capacity, and *vice versa*.

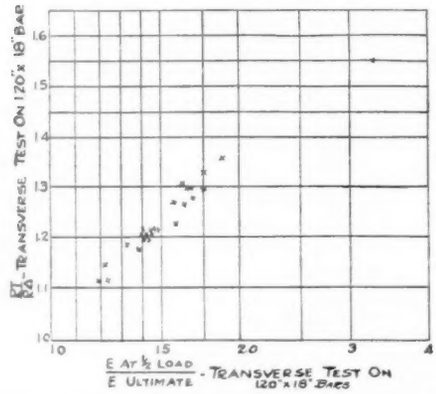

FIG. 9.—RATIO OF TRUE RESILIENCE TO TRIANGULAR RESILIENCE OF 1.20 × 18 IN. BARS TESTED TRANSVERSELY COMPARED WITH RATIO OF E AT ½ LOAD TO E ULTIMATE OBTAINED IN SAME TEST.

Permanent set phenomena are described in the symposium previously cited. Cast iron never shows complete elastic recovery from first loading but if not stressed too high, 80 per cent., its behaviour after some five or six loadings will be perfectly elastic, although the stress-strain curve still is not a straight line. The amount of set appears to be a function of the amount, size and shape of the graphite particles. Those are exactly the same properties that determine the slope and shape of the stress-strain curve. While the transverse test can be applied readily to the direct determination of set, yet, as is shown in Fig. 8, a calculation of E at the stress contemplated gives a good idea of the set to expect. (The iron so badly out of place, that at 13.3 E, is a high-phosphorus iron (2 per cent.) of low strength.[5])

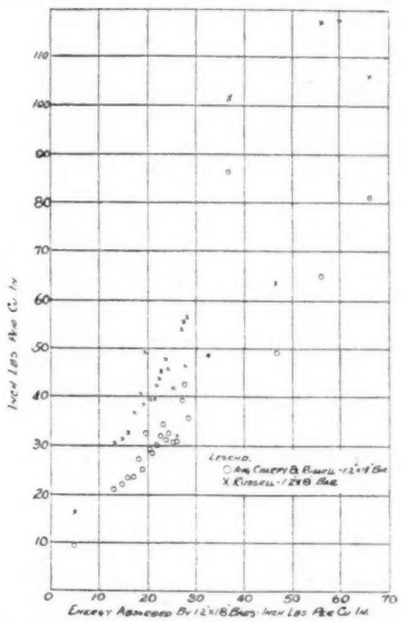

FIG. 10.—ENERGY OF PENDULUM IMPACT TESTS COMPARED WITH TRANSVERSE RESILIENCE ON 1.20 IN. DIAMETER BARS.

Machinability, which is influenced largely by the graphite formation, is estimated easily from the bending curve. An iron of good curvature, as C Fig. 1, always will show better machinability than one like A if the hardness of the two is approximately the same. Another important property in cast iron which can be calculated readily from the transverse test is toughness, which is expressed commonly as impact value or resilience. As there is no standard impact test for cast iron, the best evaluation of toughness is the work done in breaking a transverse specimen. This is called resilience. It is defined as the area under the stress-strain curve divided by the volume of the specimen which gives values in inch-pounds per cubic inch.

A planimetric measurement of the area under the load deflection graph is quite simple. Other methods, such as counting squares, will suggest themselves at once to the engineer. Even the $\frac{\text{Loan} \times \text{Deflection}}{2}$, the area of the triangle under the curve, gives a useful comparative figure. As shown in Fig. 9, by taking a ratio of E at ½ load to E at failure, the ratio of full area to triangle can be approximated with considerable accuracy.

Actual correlation of resilience and impact results is shown in Fig. 10, taken from the report

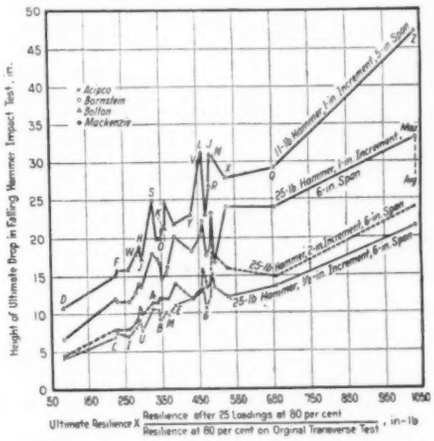

FIG. 12.—RELATION BETWEEN FALLING-HAMMER TESTS AND RESILIENCE AFTER REPEATED LOADING ESTIMATED TO 100 PER CENT. LOADING FROM THE CHANGE IN RESILIENCE AT 80 PER CENT. LOADING CAUSED BY 26 LOADINGS.

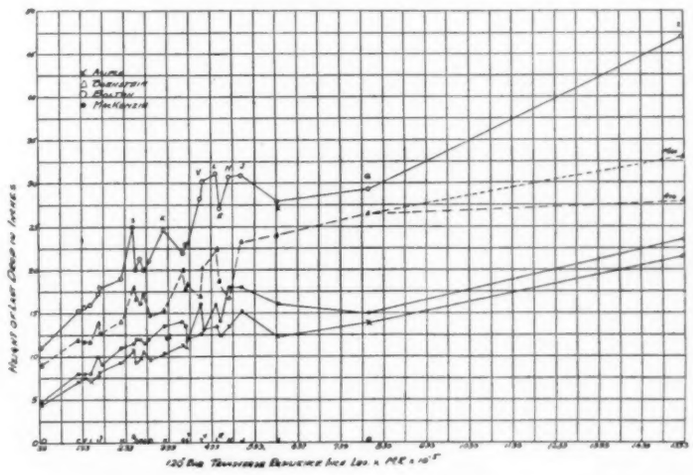

FIG. 11.—FALLING-HAMMER IMPACT ON 1.20 IN. DIAMETER BARS IN INCHES OF DROP COMPARED WITH TRANSVERSE RESILIENCE × MODULUS OF RUPTURE OF 1.20 IN. DIAMETER TRANSVERSE BARS.

of Sub-Committee XV, previously cited. These impact tests were made by the single-blow machines, such as the Charpy and Russell, which measure the energy left in a swinging pendulum after breaking the bar. Another type impact test, the drop test, which long has been used for cast iron, is that in which a weight is dropped on the specimen from a certain height. The height is increased by a certain amount for each successive blow. The height of the last blow, which breaks the specimen, is recorded as the impact value of the bar. This test, as might be expected from the discussion of *set*, measures

[5] Meyersberg has shown a beautiful correlation between set and the exponent in the Bach Formula for the Stress Strain Curve $P = af^m$ where P is load; f the deflection; and a and m, constants of the particular material and the kind of test. His formula, calculated from metric units, is: Set per cent. = $\frac{340}{m+1} - 170$.

the resilience of the material *after repeated* loading instead of the resilience of the original material. It shows a very good correlation with the product, resilience × strength, as shown in Fig. 11, and an even better correlation with the residual resilience after repeated loading, as shown in Fig. 12. The residual resilience used in Fig. 12 was calculated from the results of repeated loading to 80 per cent. If tests had been made at 90 to 95 per cent., the correlation undoubtedly would have been much better. The transverse test is applied much more easily to large sections and is a better criterion of their strength and stiffness than either the tensile or compression test. A tensile test on an 8 × 10 in. section is almost unthinkable, but a transverse test is well within the range of many large testing machines.

A tensile specimen, as ordinarily taken, would represent only the weak core of such a section, while the transverse test would stress mainly the important outer layers of the material. Taking the standard A.S.T.M. bars as an example, the area of the inner core used for the tension test shows the following ratios to the area of the as-cast bar which is tested in transverse:—

Bar.	Diameter as-cast.	Diameter tensile specimen.	Area tensile section / Area transverse section
A	0.875	0.505	0.33
B	1.20	0.798	0.44
C	2.00	1.250	0.39

This inside core, especially in the softer machinery grades of cast iron, often will show only 60 per cent. to 70 per cent. of the strength

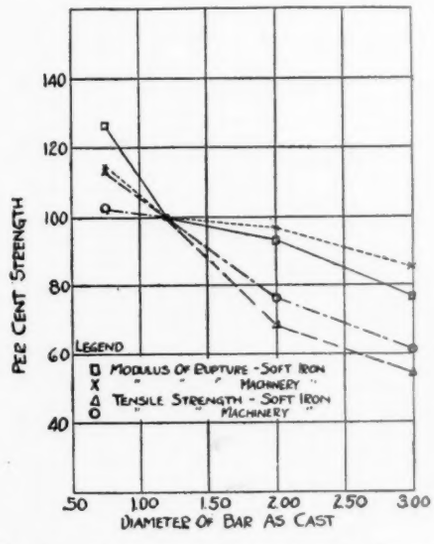

FIG. 13.—VARIATION OF STRENGTH WITH SECTION.

of the outer material and is misleading to the designer using heavy sections. The relative loss in transverse strength and tensile strength is well illustrated in Fig. 13, taken from Bornstein's data.[6] The actual values of tensile strength and modulus of rupture are shown in Table II.

TABLE II.—*Tensile Strength and Modulus of Rupture Values found in Two Grades of Cast Iron.*

Dia. of bar as-cast in in.	Machinery iron.		Soft iron.	
	Tensile strength.	Modulus of rupture.	Tensile strength.	Modulus of rupture.
	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.
0.75	37,100	70,600	28,000	54,000
1.20	36,000	61,400	24,500	42,400
2.00	27,500	59,800	16,800	39,300
3.00	21,900	52,500	13,300	32,600

A designer using a 3-in. or heavier section of these irons would be much nearer the truth using the transverse values than if he used the tensile test as a basis of strength. It probably is not amiss to call attention to the many applications of modulus of rupture to the design of cast-iron parts. Rings, arches, long columns, etc., whether in tension or compression, are transverse loadings and should be calculated from modulus of rupture just as beams should be. The reputed unreliability of the transverse test is due partly to its sensitiveness, which is really a point in its favour, and partly to the low regard in which the test has been held, both by the foundryman, designer and inspector.

Pipe Data Cited

As an illustration of the comparative variations to be expected in actual tensile strength and modulus of rupture of merchantable castings, data is available from a number of tests made at the University of Illinois, Urbana, Ill., on cast-iron pipe in 6-, 12- and 20-in. sizes. Tensile-strength values were obtained from the actual bursting of full-length pipe with internally-applied water pressure. Modulus of rupture values were determined from compression-ring tests varying from 1 to 12 in. in length on pipe made under commercially identical conditions. As the committee has not yet released these results, it would not be proper to state the absolute values obtained, but the relative values are as follow:—

	Tensile strength.				Modulus of rupture.			
	n	$\bar{X}$	σ	$\frac{100\sigma}{\bar{X}}$	n	$\bar{X}$	σ	$\frac{100\sigma}{\bar{X}}$
Pit cast ..	49	100	13.7	13.7	89	293	37.3	12.7
Centrifugal (sand mould)	26	173	13.7	8.0	210	283	49.4	12.9

n = number of specimens tested; $\bar{X}$ = average value; σ = standard (root mean square) deviation.

It is apparent that the variation in the ring test is of the same order of magnitude as the variation in the bursting test and also that the use of tensile strength in designing for trench loads would result in a totally unnecessary thickness of metals since the ratio of modulus of rupture or ring strength to tensile or bursting strength is 2.9 for pit-cast pipe and 2.2 for sand-cast, centrifugal pipe. It should be pointed out that the transverse modulus of rupture gives values which are slightly more than half the compressive strength and approximately four times the endurance limit. As the ordinary applications of cast iron do not subject the material to reversals of stress, the practical endurance limit is usually higher than is shown by the usual tests in reserved bending.[7]

Summary

The transverse test is the most readily accessible source of information on the following important properties of cast iron: Strength, flexibility, toughness, damping capacity, plastic deformation, effect of section, surface condition and machinability. It is true that a complete stress-strain curve from any other test will give the same information, but such curves are almost entirely absent from the literature of cast iron. It is hoped that the simple formulas and relations given will be of assistance to the designing engineer in specifying this unique and useful material.

6 A.S.T.M. Proceedings, 1931.

7 Kommers, Proceedings, A.S.T.M., 1929, Part 2, p. 100.

Fifth International Foundry Congress

TOUR FOR OVERSEAS VISITORS

Overseas foundrymen visiting the forthcoming Fifth International Foundry Congress at Philadelphia will have an unusual opportunity, within a short space of time, to inspect and study a cross section of American foundry practice. From the time they leave the eastern coast following their arrival on October 10, until they embark for their return voyages on October 27, these distinguished Europeans will have available for their interested inspection examples of practically all phases of castings manufacture.

Recalling the courtesies extended in 1926, at the time of the second International Congress, many who are repeating their visit anticipate renewing personal contact with American friends. The exchange of information and experiences between those engaged in similar lines of work has proved the value of the international contacts.

The pre-convention tour of the overseas party will cover the period from October 10 to 22, extending from the debarkation in New York until the arrival in Philadelphia. It will embrace Buffalo, Chicago, Detroit, Cleveland, Pittsburgh, and Washington, *en route*, with preferential foundry inspection trips to Milwaukee, Saginaw, and adjacent cities, where a number of the large shops of special interest have been made available for visitation.

To provide a variety of types and classes of work, some of the leading manufacturing establishments have offered to receive parties of visitors. These include plants making various classes of jobbing work and specialties in grey-iron, steel, malleable, brass and aluminium castings, ranging from heavy machinery and rolling-mill equipment to stoves, radiators and automotive parts.

During the tour opportunity will be given to see the points of civic and historical interest in each of the large centres. A day in New York with special trips will be followed by a night ride to Buffalo. The day following will be spent in plant inspection and in a trip to Niagara Falls, where an opportunity will be given to view the Falls by night illumination before departing by night train for Chicago.

The visitors will have an opportunity to see the city of Chicago by a conducted tour, followed by a visit to the Century of Progress exposition, with a full day provided for elected trips to Milwaukee's foundry area. Similarly, in Detroit, an additional day will be provided for the side trip to Saginaw. The party then continues to Cleveland by steamer, thence to Pittsburgh, and with a daylight ride through the scenic section of Pennsylvania to Washington, where two days will be given to sightseeing in the nation's capital prior to the arrival at the Convention, October 22.

Coking Plant for Cardiff Works

The British (Guest Keen Baldwins) Iron & Steel Company, Limited, have placed with the Woodall-Duckham Company the contract for the large by-product coking plant which they are installing in connection with the reorganisation of their Cardiff works. The contract includes a battery of Becker coke ovens divided into two sections. The ovens will be arranged so that they can be heated either by blast-furnace or by coke-oven gas as required, and will have a total net production capacity of 5,850 tons of blast-furnace coke a week. The contract also comprises the supply of all oven machinery, a reinforced-concrete oven storage bunker for 2,400 tons of washed coal, a coke-quenching station and wharf and complete by-product plant for recovery of crude tar, sulphate of ammonia and benzol. The benzol plant will provide for rectification of crude benzol to motor fuel.

Roll Foundry at Gateshead

AN ARMSTRONG WHITWORTH DEVELOPMENT

In the early part of last year Sir W. G. Armstrong, Whitworth & Company (Iron-founders), Limited, entered into agreement with the associated firms—Pittsburgh Rolls Company, and Lewis Foundry Company, of Pittsburgh, U.S.A., to manufacture at their Gateshead works dealing with the heaviest plate rolls, and roll lathes of both American and British types; the whole of the machine-tool equipment was supplied by Craven Bros., Limited, of Stockport.

Both chilled rolls and section rolls are being manufactured. The former are cast in patent

FIG. 1.—VIEW IN ROLL-TURNING SHOP AT CLOSE WORKS.

rolls for all types of rolling mills. The American concerns referred to are the largest producers of rolls in the United States, their combined output, even in the present depressed times, being upwards of 2,000 tons per month, which in itself is ample evidence of the quality

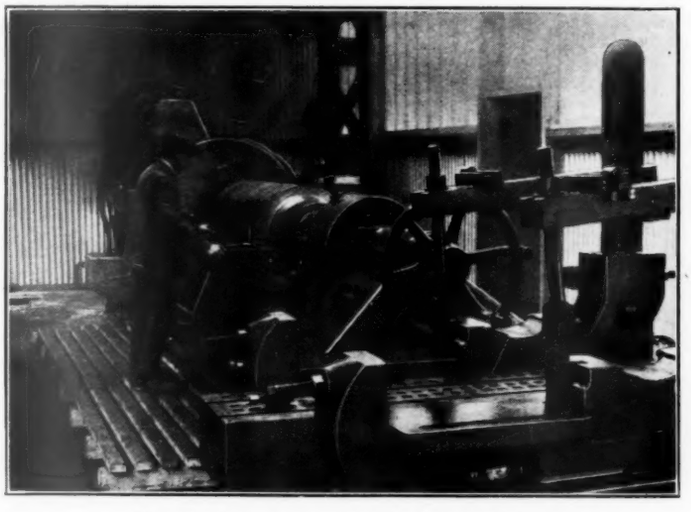

FIG. 2.—ONE OF THE ROLL-TURNING LATHES.

of production. The value of their accumulated experience is available for the British company.

At the Gateshead works a new shop has been allocated for roll production. This shop has a length of 540 ft. with a width of 55 ft. There is a liberal service of overhead cranes which range up to 30 tons capacity. The shop is equipped with a full range of the most modern machines, which includes grinding machines for diagonal slotted chills, which give a particularly uniform chill. A molybdenum content is advocated for most types of chilled rolls. This has proved in extensive use in the United States, to give a better finish and longer life, chiefly due to the fact that the presence of molybdenum gives increased strength and ensures a good product from the rolls even after the chill has worn into the mottled iron. This type of roll is made with a scleroscope hardness of 70 and over. A nickel chilled roll is also manufactured, having a scleroscope reading of 70/75. This type of roll is used for rolling high-grade steels.

An interesting development is the special hard "Phoenixloy" roll, for which patent rights have been applied for. This type of roll has a scleroscope hardness of between 80 and 90, a hardness which is maintained at all temperatures up to 600 deg. Fah. Obviously such rolls could only be put in service where roll dressing is done by grinding, its hardness being too great for ordinary cutting tools. Despite this disadvantage this type of roll is extensively used in the United States for hot rolling of stainless steel, cold rolling of steel strip and finishing brass. The transverse strength of "Phoenixloy" is more than double that of chilled iron, and its resistance to spalling is in part due to the

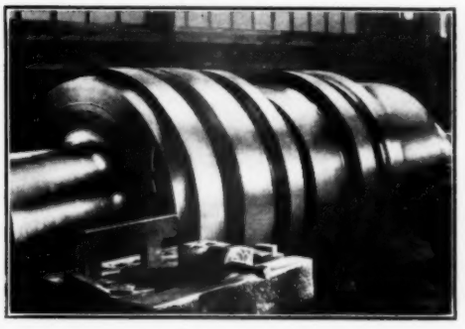

FIG. 3.—TURNING A "CLOSELOY" "A" ROLL FOR ROLLING RAILS. FINISHED WEIGHT 11 TONS.

depth of hardness. Another interesting production at the Gateshead Works is "Closeloy" metal rolls, used for many types of section work. "Closeloy" metal is a nickel-chrome heat-treated alloy with an iron base. It has a strength equal to high carbon steel and a finish approximating chill. These rolls are being extensively used on high tonnage billet and sheet bar mills, and have been found to give, in many cases, two or three times the tonnage obtained from ordinary grain rolls. "Closeloy" requires an extensive heat-treatment, and for this purpose a furnace has been installed capable of taking rolls up to 40 tons in weight, and reaching temperatures up to 1,200 deg. C.

The melting plant consists of a battery of Sesci rotary type furnaces, which is capable of melting 60 tons of metal in 10 hrs. The furnaces

FIG. 4.—ROLLS BEING CHARGED TO GAS-FIRED ANNEALING FURNACE.

are fired with pulverised fuel. Air furnaces are also installed, these too being fired with pulverised fuel.

Mr. C. N. Arnold, of the Lewis Roll Company, is staying for about a year at the Gateshead Works in order to give the technical advice and assistance available from the American Associates. The new developments at Close Works are further evidence of the enterprise so characteristic of the directorate of Armstrong, Whitworth & Company (Iron-founders), Limited, who have never hesitated to exploit a new field of activities. Already several hundreds of tons of rolls have been manufactured at the Gateshead Works.

Foundry Facings

By H. N. Bassett, A.I.Mech.E., Chief Chemist, Egyptian State Railways

If cast iron be poured directly into a sand mould it will not strip properly, the sand forming the face of the mould having fused and adhered to the casting to a greater or less degree. The result is an extremely bad surface necessitating a good deal of extra work to make it presentable. Some kind of facing material is essential, therefore, and the more refractory this is the better will it be, other things being equal. The material available may be divided into two classes of which one contains those of a carbonaceous nature, and the other non-carbonaceous facings. Of the former, graphite, coke and charcoal are the best known, and of the latter category ground silica and soapstone are the most used. Of them all there is little doubt that graphite is by far the best, not being approached in efficiency by any of the other facings.

Sources of Graphite

When of the best quality, graphite is a very pure form of carbon which crystallises in the rhombohedral system, and is known also as plumbago and popularly as black lead. It was first recognised as a mineral in 1565 and was confused at first and for some years with a molybdenum mineral, molybdenite. Graphite is found in various parts of the world, and especially in Ceylon, India, the United States, Bohemia, Northern Italy, Madagascar, Russia, Canada, Siberia and in England, and the best quality of all comes from Ceylon. That which is obtained from Borrowdale, in Cumberland, is of excellent quality, but the deposits are nearly worked out. Large quantities of graphite are now made annually in the electric furnace and employed in colloidal form in many directions, notably in lubrication and the manufacture of electrodes.

All graphite is of a flaky nature, and that from Ceylon is claimed to have a larger covering surface than any other kind. It sticks well to the face of the mould, and is not washed off by the metal as it rises. It has a greasy, unctuous feel, and some foundrymen say that this militates against good adhesion, and that some other qualities, particularly the poorer ones which are almost amorphous, are better because particles enter the face of the mould in the same way as a pencil leaves its mark on paper. The following may be taken as typical analyses of graphite from various localities:—

	Borrowdale.	Bavaria (Passau).	Ceylon.	Canada (Buckingham).
	Per cent.	Per cent.	Per cent.	Per cent.
Carbon	91.55	81.08	79.40	78.42
Moisture and volatile matter	1.10	7.30	5.10	1.82
Ash	7.35	11.62	15.50	19.76

Assessing Values of Graphite Facings

Carbon is an extremely refractory material, and therefore it might be thought that a plumbago could be judged on its carbon content alone. This is not the case, however, for if the ash content consists of non-refractory oxides (as may be the case) a graphite of high carbon content may prove less satisfactory than another in which the carbon is lower, but the ash consists of highly refractory material. It is essential that the blacking shall adhere to the mould, and with some of the best qualities of graphite this is a difficulty. Consequently various materials are added which assist the adhesion, and the greater the percentage of flaky graphite that the compounded mixture can carry the better. The amount of binder which can be added depends upon the dampness of the sand, and the drier the sand the more the binder required. If the sand be too dry in a small plate mould a spray of molasses water will make the graphite adhere which has been dusted on.

Application of Graphite

For dry-sand work the graphite is applied in the form of a wash, and the liquid mixed with it may be molasses water, or any vegetable adhesive such as dextrin. A material originating in the waste liquor of wood-pulp factories is in use in some places with very good results. To the wash, fireclay or China clay is added to improve the adhesion. Generally speaking, the higher the carbon content the greater the necessity for the addition of clay, as a really pure carbon will hardly adhere at all. Too thick a layer should not be applied, and the whole of the mould should be treated at one and the same time. If a part be done and allowed to dry off to some extent and then more be added, there is a tendency for the second lot to lift off, which leads to scabbing.

Other Facing Materials

Ground coke, retort carbon and charcoal can all be used as mould blacking, but none of them is so good as graphite for reasons which will be seen later. The ash content of the coke should be as low as possible for obvious reasons, and the fusion point should be high. It is necessary in each case to add a proportion of clay to secure adhesion.

Soapstone, or talc (also known as French chalk) has been used, and is a not unusual adulterant of cheap grades of graphite. It has a greasy feel, like graphite, and is fairly refractory, but unfortunately the combined water is driven off just before it melts, which makes for a bad surface on the casting. A high-class graphite will stand adulteration with a considerable amount of soapstone, but its use alone cannot be recommended, and the less there is of it mixed with graphite the better the results may be expected to be. Fireclay is much to be preferred as a diluent of graphite to soapstone. Silica flour is more particularly used for steel castings, and a first-class binder is required. On account of the much higher temperature of the molten metal only very pure silica can be used.

Moldenke's Experiments

Experiments were made by Moldenke some years ago on the materials used for finishing moulds, as a result of which he came to the conclusion that the important consideration was the possibility of molten iron getting into the surface of the mould in between the individual grains of the covering material. Microscopic examination showed that the surface of a casting from an uncoated mould was one mass of sand, of which the separate grains were held in a setting of iron in the same way as is a gem in a ring.

To a less extent the same thing applied with every facing material which was tried, except flake graphite. Amorphous graphite gave a similar result to the granular materials, powdered coke, charcoal, soapstone, etc., but the flake graphite resisted penetration successfully except at the edges of the flakes, and consequently the casting stripped easily and had an excellent surface. The graphite was applied with a binder and not simply dusted on or rubbed into the surface.

Flakiness Essential

The criterion, therefore, is the extent to which the facing material partakes of a flaky character, for no matter how finely ground the facing may be, the molten iron finds its way between the grains, whereas it is stopped by the flakes.

In the examination of a new sample of blacking which is offered, apart from an actual foundry test (for which the sample provided is frequently insufficient), microscopic and laboratory examination will often prove most informing. A blacking with a high carbon content but no flakiness would be likely to be less satisfactory than a graphite containing a fairly high proportion of ash, but nevertheless with the flakiness characteristic of the material.

The value of good blacking becomes evident in the cleaning of the castings, for those from moulds which have been blacked with graphite clean up much more easily and have a much better skin than castings from moulds in which a granular facing has been employed. This may be very important in some cases, especially where the castings have to be enamelled subsequently.

Establishing a Standard

It must be recognised, however, that the same blacking will not function always for every kind of casting, and that formulæ will have to be evolved as circumstances require to meet the particular needs of the foundry. The main ingredient will be graphite, and this should be purchased, so far as possible, always from the same source, and of the same quality. Nothing is more annoying than to have to change the formula frequently because successive supplies of blacking are got from different sources. Economy in blacking is false economy, and a few pounds saved on it may mean many more wasted in cleaning dirty castings or even in spoilt ones.

The mixture should be made up in reasonably large amounts and fairly accurately. Some kind of stirring mechanism will be needed, though constant agitation is not necessary. The important matter is that the mixture shall be homogeneous or satisfactory results will be lacking. Where a facing is made by a firm of specialists for a particular purpose the foundry should not alter it in any way; a perfectly good facing may be ruined by the indiscriminate addition of clay or other material.

Vitreous Enamellers First Annual Congress

The First Annual Congress of the Institute of Vitreous Enamellers will be held in Birmingham on September 28, 29 and 30. A banquet is to be staged in the Grosvenor Room of the Grand Hotel on Friday evening, September 28. A reception will be given by the President of the Institute at 7 p.m., and the banquet will be followed by dancing until 2 a.m. The Lord Mayor of Birmingham has accepted an invitation to be a guest, and several eminent men connected with industry and commerce have also intimated their intention of being present. A cordial invitation is extended to ladies.

On Saturday, September 29, the members will, at the kind invitation of the directors of the Parkinson Stove Company, Limited, visit their works at Stechford. After lunch a presidential address and technical Papers will be given at the Grand Hotel (all necessary transport being provided), whilst an interesting programme will be arranged for the ladies. A visit to the theatre will be made in the evening.

On Sunday a motor rally will be arranged to visit the numerous beauty spots in Warwickshire.

It is hoped that every member will make a special effort to support this initial venture. The future success of the Institute will, to a certain extent, depend upon the success attained at the opening congress.

Foundry Costs

An important lecture on "Foundry Costs" was delivered by Mr. F. Whitehouse, of Sheffield, at the last meeting of the West Riding of Yorkshire Branch of the Institute of British Ironfounders. The chair was occupied by Mr. R. A. Welford.

Mr. Whitehouse said he should like to make it clear in the first instance that he was speaking purely as a foundryman and not as a cost accountant. It was a case of a foundryman looking at cost accounting, not the cost accountant looking at the foundry, which was rather an important difference. None of the figures which he was going to use was actual costs. They were merely for the purpose of illustrating a principle. On the blackboard he had sketched out an economic view of what constituted price. Nearly any book of economies would give them some such chart as that, except that this one applied more particularly to founders and founders' prices. But nearly all would split up the costs into direct and indirect costs, whilst naturally they would put the final costs, plus profit, for their selling prices. He should like it to be understood that most of his illustrations were relating to some foundries with a mixed production. Most of his arguments had nothing whatever to do with the repetition firms, because these firms lent themselves very easily to most modern methods of costing.

When a foundry wished to put in a price for a casting, the first thing was to estimate the price for moulding. The beginning of the price was the estimated labour cost. Then there was the metal charge. In addition, there was the figure for overhead charges, and, of course, transport, and patterns, if any, had to be made, and finally incidentals. In the main, estimated labour charges, metal costs and overheads were rather direct costs than indirect, but selling prices were based on estimates and not on actuality. The selling price was the cause of the costing, not the cost itself. Anybody who was insisting upon a costing system in order to get a correct selling price was missing the essence of the matter. All the essential things of a price were estimated. A figure shown by Mr. Whitehouse on the blackboard was an estimation. Another figure was an estimate based on previous practice. The overhead charge in modern practice was a multiple of the others. As to the method of arriving at metal costs, the metal cost of the casting was not merely the cost of the pig-iron to make a casting, plus the amount for the melting of that quantity. They could not melt just enough pig-iron to make a casting. There was an excess which must be paid for. Moreover, there was a melting loss which must be paid for.

The proper charge was the total cost for the previous year, divided by the total quantity of tackle and good castings in tons, and that gave the metal cost in tons when putting in an estimate. His estimated figure of metal cost was 3s. 6d. per cwt., which covered the metal question. The labour itself was estimated. The next item was the manner in which they arrived at the figure to be put in for overheads.

Overheads

In a year's time all these little incidentals must be covered in the price of the goods sold, and also it was evident that nobody could exactly say what each particular casting cost in the way of indirect costs. So an estimation had to be made, and the means of arriving at that estimation was a matter of importance. The usual means of arriving at that estimation was to say that most of these costs had to do with time. It was a common practice to say that overheads cost so much per hour. Since the price of labour wages was only an expression of time, for convenience people said that overheads were a definite percentage of direct and total wages. If they took it that the total figure of costs for one week was £490, and labour costs came to £245, the overhead figure would be 200 per cent. But the amounts of the overhead charges differed according to the circumstances of each case—the number of hours spent on the job, the quantity of labour. Assume wages at 1s. 6d. per hr., the price for overheads alone would be 3s. per hr. If they assumed that the labour was 12s., the overhead charge would be 24s. Since 12s. represented 8 hrs. labour, they obtained the same result. So there was no difference between the hourly basis and the price basis. There was, for purposes of record, an advantage in putting the total figure in the books as the number of hours, and data obtained by those means were always absolute, for hours were always hours. The £245 must represent the same at different dates. Instead of taking in the books the price at 12s., they might say it took 8 hrs. For purposes of record, he recommended that as against the other method. He realised that in his costing he had to recover a certain amount of money which people called overheads, and he had to recover the cost of the iron itself and the cost of melting iron and the cost of making the job. These costs constituted labour, metal and overheads. For the moment they could ignore the incidentals. For purposes of a more practical nature, he would like to take the matter from the costing office to the foundry, because in the costing office they took only a technical view of the subject. They must remember that the melting cost was not the metal cost, because the metal cost must include items for excess metal, depreciation of plant, and quite a number of other items, and it had to include allowance for the 5 per cent. which they had to assume was the metallic loss. If the foundry has four bays—A, B, C and D—and the overheads in any one week were £490, and the total wages £245, then the overhead charge is 200 per cent. In bay A, a machine-moulding bay, 40 tons per week are produced; bay B is a green-sand bay, with no machines, the work being of such a nature that it could not easily be put on to machines; it produces 50 tons per week. Bay C is a dry-sand bay producing 20 tons per week, whilst bay D is a jobbing bay producing 20 tons per week. All these bays are of the same length, and each has two cranes. The average labour costs may be:—Bay A, 20s. per ton; bay B, 30s.; bay C, 70s., and bay D, 60s. It means that, so far as providing overheads at 200 per cent. is concerned, bay A should provide £80, bay B £150, bay C £140, and bay D £120. With the total sum of £490 equally divided, it would mean £122 10s. each as the price so far as equal shares of the overheads were to be found. It is rather instructive that by taking the flat rate of 200 per cent., one bay could manage to be so much below paying its own way, merely on the method of costing. They could take it that bay A was unduly burdened with overheads and that, should it only bear its fair share, they could manage to sell products of that bay much cheaper than was otherwise the case and still make a profit. It meant also that bay C was bearing more than its equal share. Thus overheads should be so added that each casting bears its fair share. That was the purpose of adding overheads. Bay A, with its machines, should really have more overheads, on account of distribution and combination with bay B, and should bear more than B because it had a number of stoves and other plant. The same applied in some measure to bay D. The bay A price per cwt. of castings produced was, on the average, 6s. 6d.; the bay B price was 8s.; that of bay C was 14s., whilst the bay D price was 12s. 6d.

Thus the average prices of the castings from each of these bays were best taken separately. They might instance, for comparison, a plate casting. It weighed 8 cwts. and cost 12s. by hand, and two-thirds of that price on the machine. They would find that the selling prices in the essential sense, apart from patterns and transport, would be: Bay A, 52s.; Bay B and the others, 64s. On the face of it there would be a great inducement to put all castings in the A bay because a casting seemed to be produced so much cheaper there than elsewhere. Actually the castings in bay A were produced at two-thirds of the loose-pattern price. Reversing the conditions and assuming that, having seen this difference, a firm should decide to make bay B similar and should instal machines there. They would find in that case that the total wages paid would be reduced. Bay B would then give its 40 tons per week at 20s. per ton, and the total wages that the firm paid would be £210—a reduction in cost. The overheads would increase, on account of upkeep and depreciation. Assuming that they increased to £504, then when ascertaining the next rate of overheads it would equal not 200 per cent. but 240 per cent., which involves that the price in these two bays, instead of being 6s. 6d. would be 6s. 10¾d. both in A and B. In bay C, to recover the new rate of overheads, the cost must reach 15s. 4d. and D to 13s. 8d. So, without any difference at all in the amounts of the production prices, the figures are altered merely by effect of the manner of costing.

Suppose it was then decided to make all the bays similar to B, the other overheads would probably be reduced to £400, and the wages paid would be £300. The rate of overheads would then be 133⅓ per cent., and the average price of castings in all the bays would be 7s. per cwt., even though in the first instance it had been 8s. in one case. It seemed to him to be a matter of importance that it should be realised how, by merely shifting about the figures, the prices of the same products in the case of bay B could be varied to the extent of a reduction of 1s. per cwt., and a reduction of 1s. per cwt. in any estimate was very far from being a trifle. In many cases it was enough to make anybody busy for a long time.

A Further Variation

Suppose that bay A was made like B, the overheads would be reduced slightly. The machines would be no longer operated, and there would no longer be upkeep charges to take into account. Suppose the charges per week were reduced to £450 and the wages increased to £280. The overheads would then be 160 per cent. The prices per cwt. would then be: Bay A, 7s. 4d.; B, 7s. 4d.; C, 12s. 7d., and D, 11s. 2d. Thus it was possible to have many prices for the same casting, the only difference being not that it itself had changed, or that its conditions had changed, but merely because other castings and products of the same firm had influenced the price through the medium of the overhead figure. Take it, now, that each bay paid its own costs. Each bay could definitely be allocated certain expenses, and examine the effect. Bay A should rightly find £140 per week, because of the machines and the apparatus necessary for running the machine, and Bay B £100 a week; Bay C, on account of various factors, to pay its way should contribute £130 per week, whilst D should furnish £120 per week. To recover on the bay A's products it would be necessary to charge 350 per cent. on the direct-labour figure. For B's products to pay their own way it would be necessary to charge 133⅓ per cent. on the direct-labour figure. In the case of bay C 187.7 per cent. was necessary, and on bay D 200 per cent. The average

selling price per cwt., with metal at 3s. 6d., would be: A, 8s.; B, 7s.; C, 13s. 6d., and D, 12s. 6d. Calculated in that way, no one bay would be paying for any other bay. Each bay's products would be self-supporting, and if it did not pay it would not continue to make the castings. Those particular articles for which their foundry was best fitted they would continue to produce, because they would have the advantage of the nearest approximation to the exact cost of producing the articles that they could find. By eliminating altogether that which did not pay, they would be giving one bay's products a competitive advantage. It meant practically that every product that came out of that bay could be sold at a cut price. But it was at the same time an uneconomic price, because it would not have assumed its fair share of costs. In the cases of the other products, consequently, prices would be unnecessarily high, merely to provide bay A with its opportunity of cut prices. Suppose now they considered actual castings produced in these bays, because it was easy to see that these bays might represent four different shops, and if they took these as such they would see how firms differed in quoting for castings made in the same time.

Suppose a furnace plate had to be made, weighing 10 cwts. The metal would be the same price—3s. 6d. per cwt.—for all the bays. In bay A it would cost 4s. to mould by machine, whilst in the other bays it would reach 6s. to mould by hand. In bay A the price would be 5s. 3½d. per cwt. and in B 4s 11d. per cwt. In bay C it would be 5s. 3½d. and in D it would be 5s. 3½d. For a casting weighing ½ cwt. the price of making by hand would be 1s. 8d. in B, C and D, and 1s. 3d. in bay A. The total prices would be 7s. 3d. in A, 5s. 6½d. in B, 6s. 4½d. in C and 6s. 11½d. in D. These would represent the offers that these several firms would make for making that casting. If they were making stair steps, weighing ½ cwt., the prices would be: 4s. 11½d. in A, 4s. 1½d. in B, 4s. 5½d. in C, and 4s. 7½d. in D. If this work was charged for on the basis of 200 per cent. overheads, the prices would be: 3s. 7½d. from A and 4s. 7½d. in each of the other cases. It would be selling on the old basis a cheap product, not because it had been produced very cheaply but because, owing to this manner of distributing these overheads, it was unduly burdening the other bays in order to give A a real price advantage. In these circumstances 3s. 7½d. was a cut price, an uneconomic price, and, from one aspect, an unfair price.

Sometimes they heard it said that a foundry ought, or ought not, to have a certain figure of overheads. Some people would say that they should not exceed 150 per cent., and that if they went beyond and had more than that they were distinctly running on an uneconomic basis. The percentage of overheads did not in any way indicate at all the efficiency of their costing. The essential point was that the manner of allocating overheads should be such that each casting, as far as was practicable and possible, should bear its fair share. A casting which did not recover its own costs was a cut-price casting and an uneconomic proposition, and so far as the industry was concerned it was disastrous to the firm that was doing it and to the industry in general, because no firm could compete with an article which was sold at an unfair and uneconomic price—whether the writing down was being done consciously or unconsciously. All jobs should be charged with their own costs, and the costing system should be carried so far as to include the cost of fettling. A casting ought to cost itself as far as possible. If that was impracticable, the cost of fettling the casting should be so arranged that groups of a similar nature should have a definite fettling charge added to their costs. A casting costing 2s. a ton to fettle should not have to bear the cost of fettling some castings which cost 1s. a ton to fettle. To average fettling costs between widely different castings was an unfair means of allocating overhead costs. The essential feature was to spread overheads equitably among all the products. He illustrated that question of putting overheads from the fettling bay on to the casting itself. Assume that the overhead cost in the fettling bay was £50 a week. It was an entirely separate bay and that was the cost of running it, including the cost of inspecting and weighing. Take it that the wages were £33 10s. The overhead on the article itself would be 150 per cent. If it was taken as a separate department, it meant that some of these figures from each of these bays must be reduced, because previously they included the cost of the fettling bay. Assume that £83 was taken off, B bay's overheads would then be 106 per cent. on melting, and the quotation of price would be 30s. for melting, plus 106 per cent. of 30s., reaching 32s. plus 2s. per ton for fettling, and plus 150 per cent. of 2s. as the fettling basic overhead cost which would be 3s. Calculated in that way, the price per cwt. would be 6s. 10d. Calculated in the previous way, it would be 7s., because the fettling-bay costs had been brought from the four bays and B bay had had to bear an unfair share. Separate them and add them separately to the estimate, and in this particular instance they could manage to sell castings for 6s. 10d. for which formerly they would have had to quote 7s. This separating and splitting up of overhead charges would mean that on competitive lines they would sell more advantageously and, in regard to unremunerative lines, they would be able to see more clearly that these did not pay.

DISCUSSION

MR. W. G. THORNTON thanked Mr. Whitehouse for the lucid manner in which he had treated the subject, which was difficult because it required such a quantity of figures to illustrate it. He thought it would be a good thing if Mr. Whitehouse would approach the costing accountant's association and place these figures before them. The lecturer had shown very forcibly how figures could be "managed" to obtain the result required. He was glad also that the speaker had emphasised the need of separate charges for each section. It was impossible to run a foundry with various sections on one uniform cost. He personally took his figures for three months. Another good thing was to base all their costs on hours.

MR. WHITEHOUSE said that people did not quite appreciate how very much costing was a practical proposition. It was useless to put in a clerk who had never been in a foundry and ask him to instal a costing system for them. It was essential to have exact costs, because the mere fact alone that one was selling something successfully did not always mean that they were working at a profit. For that reason, he thought separate costs were necessary. The exact purpose of adding overheads was to get the exact proportion that a casting should bear. They could not, in fact, find individually what costs a casting should bear, but they had to have a close approximation. The costing system had provided data for the intelligent foundryman to give an intelligent estimate. The selling price could not be based exactly on costs. They must be based on somebody's estimate of what the costs would be.

MR. S. CARTER asked how Mr. Whitehouse had arrived at his overhead costs.

MR. WHITEHOUSE said it was a practice to get a fresh overhead figure according to the expenses of each month. Therefore it was necessary to vary the rates of overheads added to the costs of the job. It was fairly easy to ascertain whether the works bill was £490 or £500. Some of the charges were direct charges—standing costs which did not vary—whilst the variable charges did not change greatly in a month. They would not suddenly have five times as much on any item. Therefore the cost was a fairly stable figure in any firm over a given period, unless prices were fluctuating very widely at some time.

MR. CARTER: In the case of a month's turnover being 50 per cent. less than in the previous month, if one has based his charges on the previous month's figure, what is the result?

MR. WHITEHOUSE said he thought that, for the purpose of adding overheads, it was necessary to take the normal figure. Otherwise, they would be penalising sales in some months and falsely promoting them in other months. With certain firms the standing charges allow for the fluctuations of output. Taking them over the 12 months these charges pretty well balanced themselves.

MR. S. W. ANSON said that it seemed to him that neither one month nor two months was sufficient to test this matter in the foundry. The overheads were still running along in times of depression. The overheads should, he thought, be taken over as long a period as possible. Six months was little enough. He found that if they took any shorter period the overheads amount was apt to make difficulties for them. He understood Mr. Whitehouse to state that he thought costs should be taken on the job. He personally thought the better way was to take it per set of castings. First get the drawing or pattern, which would give a fairly good idea of the type, and they could then get an approximation. He found it very difficult to fix a price on an all-round job unless that was done. Sometimes they had to take a job quickly and forget overhead charges, because if they were to delay they might lose the job. He would be glad of a suggestion of some method whereby they could split up the overhead costs into categories.

MR. WHITEHOUSE said the essential thing was to know what the job would require in hours. The cost accountant only put in figures based on previous figures. It was the knowledge of the man in the foundry that really mattered. If he judged wrongly, no cost accountant could put him right. The foundrymen should have much more control over this matter of costs than was usual.

MR. A. S. WORCESTER said he thought the lecture should have been entitled "The Allocation of Overheads." From the costs point of view in the competitive foundry, Mr. Whitehouse had barely done more than touch the fringe of the subject, because the allocation of overheads was a detail. It was a factor that was not forgotten in estimating costs as the other points. If a man was in competition for a job, although his overhead costs were much higher he might get the job all the same. He had hoped that they were going to hear something which was going to help nine-tenths of the founders, who did certainly want some standard system of costing. Certainly, every man ought to know what his costs were. He was afraid the mentality of many of them would not help them to find out their costs. Some men, for instance, would spread their pattern-making costs over the whole foundry. He did not think that one foundryman in ten dealt properly with his costings. He quite agreed that overheads were not dealt with correctly, but so far as competitive foundries were concerned, the other factors in costing were far more important.

MR. WHITEHOUSE said perhaps it was a correct view that he had only dealt with a simple phase of costing, but he had been endeavouring to press the point, which seemed to him to be important, that a casting must bear its share of the overheads, though only its share.

MR. WORCESTER asked what Mr. Whitehouse would consider to be a proper costing system for shop scrap.

MR. WHITEHOUSE said he should put on the market value of scrap. If scrap could be bought outside the shop at 40s., that was the value of the scrap. He took account in his costings of the loss of metal in melting, which on the average he reckoned at 20 per cent. In some

(*Concluded on page* 138.)

Soft Cast Iron*

By L. W. Bolton, A.M.I.Mech.E.

In certain types of castings, usually those of a fairly light nature, softness and good machinability are essential qualities, and from time to time the British Cast Iron Research Association receives inquiries from members as to the best means of regularly producing castings which can be easily machined at high speeds. Occasionally trouble has been found to be due to castings which have chilled and become mottled or white in thin sections, and such areas can only be machined by tools of the tungsten carbide type. The average machine shop, especially where castings are being machined on a continuous production basis, cannot be expected to deal with them. Such castings can only be rendered easily machinable by annealing.

Often when complaints are received that castings are hard, examination shows them to be uniformly grey. Such castings should not present any machining difficulties if the machining is done slowly, but present-day methods in many machine shops demand castings which are very easily machinable at high speeds. To meet these conditions many firms are arranging for castings to be heat-treated before machining, and the purpose of this report is to discuss first the best means of obtaining castings which are as soft and machinable as possible in the as-cast condition and, secondly, the heat-treatment necessary to impart maximum machinability and softness to such castings.

The Influence of Composition on Machinability

Phosphorus.—Unfortunately the type of casting on which maximum machinability is usually wanted is the most difficult type for the foundryman to produce in a soft iron. In the first place, it is necessary, either on account of cost, or in order to obtain an iron which will run thin sections, for the phosphorus content of the metal to be high, and in order to obtain the highest machinability the lower this element the better. Phosphorus is present in grey cast iron as phosphide eutectic, which is a hard and brittle constituent. Small amounts of phosphorus produce a large amount of the eutectic, in fact, with a phosphorus content of 1.0 per cent. over one-eighth of the cast iron will be composed of this undesirable material. Phosphorus tends to stabilise, and so to retain in the casting, pearlite, which is another relatively hard material, and this element also reduces the amount of carbon the iron can hold, which again tends to reduce the machinability of the casting. In castings which are to be easily machinable and where high phosphorus is not essential for fluidity, this element should not exceed 0.5 per cent., at which figure its hardening effect on the metal becomes pronounced.

Total Carbon.—Where softness is the main consideration the total carbon content should be high, and although the amount the iron will hold is influenced by the amount of silicon and phosphorus present a figure of at least 3.5 per cent. should be attained. The reason is that high total carbon irons tend to give a low Brinell hardness, which is usually the basis on which machinability is judged. The large amount of graphite in a high carbon iron, especially when it is in a fine-divided form, breaks up the matrix and lessens the resistance of the metal to the tool.

Where the graphite is in coarse flakes, however, especially if these are of a "kishy" nature, although metal may be removed rapidly, the wear on the tools has been found to be rather severe. This is rather difficult to explain, as graphite of itself is soft and would be expected to have a lubricating action during machining. The difficulty experienced may be due to non-metallic impurities, which have become trapped in these coarse flakes and which have an abrading action on the tool.

Silicon.—This is another very important element from the point of view of machinability, and acts in two ways. As is well known, a certain amount of silicon is essential in order to ensure the iron being uniformly grey, and increasing the silicon will further soften the iron up to a point by decomposing the pearlite and producing ferrite, which is a very soft constituent. This element, however, reduces the total amount of carbon the iron will hold, and it also has a hardening and embrittling effect on the ferrite if present in too large a quantity. In irons of medium section, say between 1-in. and 2-in. thickness, a silicon content of about 2 per cent. with the total carbon previously recommended will be found to give good machinability. For thinner sections the silicon must be higher, but should not greatly exceed 3 per cent., even in very light castings.

Manganese and Sulphur.—Manganese and sulphur, although usually present in very small quantities, can have an influence on the hardness of the casting. Ideally these elements should neutralise each other, as either, if present in excess, will exert a hardening influence, sulphur being more drastic than manganese in this respect. In order completely to neutralise the sulphur, the manganese content should be 1.7 times the sulphur content, plus 0.3 per cent. For example: a sulphur content of 0.10 per cent. requires 0.1 per cent. × 1.7 plus 0.3 per cent., or 0.47 per cent. manganese to render it harmless. Manganese present in excess of this figure will have a slight hardening effect, but is preferable to having insufficient manganese to neutralise the sulphur present.

To sum up, in producing iron which is to be easily machinable in the as-cast condition, the following points should be borne in mind with regard to the composition: (1) The phosphorus should be as low as possible, and except in very light castings should not exceed 0.5 per cent.; (2) the total carbon should be as high as possible, but coarse "kishy" flakes should be avoided; (3) the most suitable silicon content will depend on the section of the casting, but should not exceed 3.0 per cent.; when present in excess it has a hardening effect, and (4) the sulphur and manganese contents should be in balance, but free manganese is preferable to free sulphur.

Annealing

Grey castings are usually annealed for one of the following reasons: (1) To obtain maximum softness and machinability in an already relatively soft grey iron; (2) to render soft and machinable castings which contain hard, mottled, or white areas, which are practically unmachinable, and (3) to relieve casting stresses. These treatments are all known as "annealing," although there are essential differences between each, and this has led to some confusion in the industry.

Annealing Grey Cast Iron

Where already uniformly grey castings are annealed to increase their machinability it is necessary to break down as completely as possible any combined carbon, which will be present either as pearlite, or as a constituent of the ternary phosphide eutectic, to ferrite and graphite. In normal grey cast irons the combined carbon will begin to break down at a temperature not greatly exceeding 400 deg. C., but at such a low temperature the structural change would take a great many hours to be completed. It is normally more convenient to heat the castings to a much higher temperature where the change is accomplished fairly rapidly.

While this treatment will certainly lower the Brinell hardness and increase the machinability, it should be borne in mind that this is accompanied by a fall in the strength properties of sometimes up to 30 per cent. For this reason such treatment is definitely a disadvantage where castings are required after machining to withstand fairly high stresses.

The usual practice is to heat to a temperature 10 to 20 deg. C. above the critical temperature, and after maintaining at this heat for a short time, say 30 min., cool slowly to a dull-red heat. The period at the maximum temperature is necessary to ensure that the whole of the carbide present goes into solution, but the major portion of the carbide is broken down during the cooling, which is an important part of the process. The slower the cooling the more opportunity is given for the whole of the carbide to decompose, and if possible the cooling from the annealing temperature to a dull-red heat (500 deg. C.) should occupy at least 1 hr.

The critical temperature of a pure carbon alloy on heating is 730 deg. C., but in cast iron this temperature is higher, because of the presence of silicon. The critical temperature is raised roughly 30 deg. C. for each 1 per cent. of silicon present. For normal cast irons, therefore, containing 2 per cent. silicon, the castings should be heated to 800 deg. C.—810 deg. C. Any manganese in solution in the iron also affects the critical temperature, but in the opposite direction to silicon, reducing the critical temperature by approximately 25 deg. C. for each 1 per cent. of manganese. In normal grey cast irons, however, as already explained, the major portion of this element is combined with the sulphur, and as far as its effect on the critical temperature is concerned this element may be ignored.

A typical grey casting of the following analysis: total carbon, 3.58 per cent.; silicon, 1.68; manganese, 0.69; sulphur, 0.10, and phosphorus, 0.43 per cent., had a Brinell hardness of 217 and would be considered rather hard for high-speed machining.

The same iron after soaking at 810 deg. C. for 30 min., followed by slow cooling for 45 min. from 820 to 500 deg. C. After this treatment the casting had a Brinell hardness of 120 and was very easily machinable. The whole of the pearlite present in the original casting has been broken down to free carbon and ferrite, the free carbon having been deposited on the original graphite flakes.

Annealing Castings Containing Hard Areas

Castings which have chilled either to mottled or white iron in certain areas owe their hardness to the presence of relatively large amounts of combined carbon, which is present in a more massive form than that met in irons which are uniformly grey. This free carbide is naturally more difficult to break down and it is usually found necessary to heat to approximately 50 deg. C. above the critical point and maintain this heat for a period of up to 4 hrs., according to the amount of carbide present, followed by slow cooling as described previously.

The structure of a localised area of white iron which was present in a grey casting was extremely hard and unmachinable with ordinary tools, yet after soaking at 830 deg. C. for 3 hrs., followed by slow cooling over a period of 1 hr. to a dull red heat, all the massive cementite crystals originally present was broken down, and the structure now consisted of temper carbon and ferrite. The analysis of this metal was:—Total carbon 3.28, silicon 2.35, manganese 0.88, sulphur 0.16 and phosphorus 0.06 per cent.

In the heat-treatments suggested above it is, of course, assumed that the castings contain no

* Extracted from the Bulletin of the British Cast Iron Research Association.

XUM

alloying element, the most dangerous one from the point of view of machinability being chromium. This element has a very strong stabilising effect on the carbide, and the presence of even a small amount will make it necessary that either the annealing is carried out at a higher temperature or that the time taken over the operation is longer.

Extreme care should be taken to see that no chromium enters the metal where softness is desirable. The warning is necessary in view of the increasing use of this element in some branches of the founding industry, and the British Cast Iron Research Association has sometimes found appreciable amounts present in castings which have failed to give good machinability. In every case it has entered the mixture from purchased scrap, and if such scrap is used care should be taken to see that it contains no cylinder blocks or other automobile castings, or castings which have been used for heat- or wear-resistance.

Manganese also has a similar effect in stabilising the carbide in cast iron, but in this respect is much less drastic than chromium. Only the manganese which is in excess of that required to neutralise the sulphur will act in this way, but where the manganese content is known to be high in relation to the sulphur content it is advisable to anneal for a rather longer time or at a slightly higher temperature to ensure complete softening.

In softening castings by a relatively short heat-treatment it is not generally necessary to use any packing material, although this is a safeguard where very thin castings are being annealed and where very slight warping must be guarded against. The main disadvantage from its use is that a much longer time must be allowed for the box to become thoroughly soaked at the annealing temperature. Packing in iron turnings or coke dust does, of course, assist in preserving the skin of the castings and in avoiding scaling, but the same effect may be obtained by using boxes which can be kept air-tight during the annealing operation.

Where the castings are to be freely machinable after annealing it is essential that scale (which is iron oxide) shall be prevented from forming on the surface, as this is extremely hard, and is bound to cause difficulties in the machine shop. The only means of preventing scaling in ordinary gas or coke-fired furnaces is to make sure that the castings are not in contact with the furnace atmosphere, either by using a packing material or boxes which are practically air-tight.

Annealing to Remove Casting Stresses

Annealing to remove casting stresses is not a softening process, but is thought so because the treatment is sometimes confused with those already described. In certain castings, usually those of a large and intricate nature, it is often necessary to remove casting stresses before final machining, in order to avoid warping in the finished castings. This treatment will also reduce the risk of some highly-stressed member cracking in service, and has been found especially advantageous for castings of low total carbon where the stresses set up on cooling are particularly high.

At one time it was usual to machine the surface of such castings and then leave them for a period of days or even months, as it was known that these stresses would be relieved at room temperatures after a certain time. This process was known as ageing or seasoning. Owing to the time lost and also to uncertainty as to when a casting is in a stress-free condition by this method, it is now more usual to anneal such castings at a low temperature, and this process is sometimes known as artificial ageing. The best results are obtained when the castings are skin-machined before the treatment, which consists of slowly heating to approximately 400 deg. C. and maintaining at this temperature for 6 to 8 hrs., according to the nature of the castings, followed by cooling in the furnace.

The temperature of 400 deg. C. should not be greatly exceeded, as it is very important that no carbide break-down should take place. As previously explained, this will begin to take place slowly at temperatures above 450 deg. C., and it is therefore important that the temperature should never exceed 500 deg. C. At such low temperatures it is not necessary to make any provision against scaling, and the castings may simply be placed in the furnace without any covering. No loss in strength should result from the treatment, and it has sometimes been found that a slight increase in strength has resulted, due, probably, to the release of internal stresses.

Foundry Costs

(*Concluded from page* 136.)

cases the metal melted might be twice the weight of the casting. In some cases the cost of melting might be as much as 11s. per ton. The iron would, perhaps, cost £3 per ton, and if the cost of melting was 11s., there must be a charge of £3 11s. at any rate, ignoring for the moment the loss in the melting, which might easily bring the figure to £3 14s. Thus, for a casting which weighed a ton, it took 30 cwts. of iron to run it. For melting costs they had 11s., plus 5s. 6d., and there would be a loss on 30 cwts. which would cost 5s. Thus the iron actually in the casting cost £3, and a total of £4 1s. 6d. was needed to meet the charge for the casting. That was what was required merely to cover costs.

MR. ROXBOROUGH said that supposing they had to deal with some particular kind of casting, say a grain roll, they would have to buy special iron at perhaps £5 10s. per ton. When they went to make another casting they used the scrap in the furnace and reduced the quantity of new iron by that amount. That scrap was probably worth £7 per ton. For the purpose of selling that second casting they would have to put that scrap in the estimate at £7 per ton, so as to get a good selling price for the grain roll, and he thought that was the sort of idea that had been disturbing the minds of some of the audience. They could sell grain-roll scrap on the market at probably £3 a ton, but for their estimate, to get their selling price for the article, they would probably put their metal in at £7 per ton, because it was supposed to be a very special iron, specially prepared. As an asset it was only worth, say, £3, but as an estimate for the selling price of a casting it would be reckoned at £7 per ton.

MR. WHITEHOUSE said the actual value was what they could get the iron at in the market—what it was worth to them or to anybody else. If a competitor was wise enough and quick enough to buy that scrap since they were working on a higher charge than he was—the difference between £7 and £3 5s.—the competitor should be able to run them off the market. They could not, in costing, charge any fancy figure they liked. They could only safely try to recover the average price of the kind of iron which was put into the casting.

A very hearty vote of thanks was awarded to Mr. Whitehouse for his lecture.

Compensation for Silicosis and Asbestosis

The Home Secretary gives notice that on August 4 he made a scheme under Section 47 of the Workmen's Compensation Act, 1925, as extended by the Workmen's Compensation (Silicosis and Asbestosis) Act, 1930, amending that part of the Silicosis and Asbestosis (Medical Arrangements) Scheme, 1931, which relates to the initial and periodic examination of workmen employed in occupations included in the first schedule to the scheme The new scheme will come into force on September 1, and may be cited as the Silicosis and Asbestosis (Medical Arrangements) Amendment Scheme, 1934. Copies of the scheme may be obtained from H.M. Stationery Office.

Behaviour of Manganese, Silicon and Carbon in Steel Manufacture

Pig-iron and scrap are converted to steel at temperatures between 1,500 and 1,700 deg., the chemical reactions in this transformation occurring mainly between the molten iron and the molten layer of slag; the preparation of the hearth also determines the nature of these complex reactions. According to a Paper on the behaviour of manganese, silicon and carbon in steel manufacture, read by PROF. DR. F. KORBER at the recent annual meeting of the Verein deutscher Eisenhüttenleute at Düsseldorf, the Kaiser Wilhelm Institut für Eisenforschung has made a careful study of these reactions in the laboratory, the conditions governing them, their equilibrium characteristics and inter-relationship. Up to the present, these investigations have given an insight into the reactions of manganese and silicon in the melt with iron oxide, manganese oxide and silica in the slag for various ranges of concentration in the two phases and for temperatures from 1,500 to 1,700 deg. To study the conditions obtaining with an acid furnace lining, experiments were conducted in sand crucibles, to enable the equilibrium constants for the iron and slag melts to be determined for a high excess of silica. This excess of silica in the reaction system produces complete saturation of both melts with silica and as a result there is a close relationship between their concentration values, which considerably simplifies the equilibrium conditions. These equilibria are also of value in interpreting deoxidation phenomena, the composition and state of aggregation of the products resulting being deducible from the equations obtained.

Equilibrium data could, however, only be correlated with practical observations after further laboratory experiments had been carried on the influence of carbon on the equilibrium constants and the course of the reactions. The displacement of the equilibrium constants and concentrations by the formation of carbide in the melt was thus studied up to high carbon contents. It was found that in the range up to about 1 per cent. of carbon the effect produced was very small. A far greater effect on the course of a reaction is, however, exercised by the carbon acting as a reducing agent. Reduction causes an increase in the silicon content of the melt which far exceeds that to be expected from the equilibrium conditions in the molten slag. Selective reduction of the metallic oxides causes an accumulation of silica in the slag, which may proceed so far that eventually the melt and the slag are separated by a layer of silica, the carbon in the melt preferentially reducing the silica. The existence of this reaction was confirmed by observations on actual melts in an acid open-hearth furnace. The mechanism of the reaction, which was closely followed throughout the melting period, was interpreted on the basis of the results obtained in the laboratory. The equilibrium conditions between the metal bath and the slag during the first part of the melting process were later completely masked by the active reduction of the carbon. It has thus been shown that conclusions drawn from laboratory experiments on the mechanism of fundamental metallurgical reactions are valuable indications of the course of the reactions taking place in actual furnace practice.

German Metal Restrictions

In view of the metal shortage now being experienced in Germany owing to restrictions on imports, the German Government has forbidden until further notice the use of copper or nickel for lightning rods, for electric wires of more than 25 sq. mm. section, for roof or floor covers and for radiators, shop signs and medals. Tin must not be used for the production of solder sticks or for tinning wires, while the use of mercury is forbidden for the production of vermilion. These restrictions do not apply to goods specially manufactured for export purposes.

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This Week's News in Brief

Trade Talk

A NEW FOUNDRY has been opened at the Audley Engineering Works, Newport, Salop.

GLASGOW CORPORATION has placed an order for pipes worth £3,103 with Messrs. Cochrane's Foundry, Middlesbrough.

MESSRS. COX & DANKS, LIMITED, iron and steel merchants, shipbreakers, etc., have established an office at Frederick Road, Pendleton, Salford, 6.

MESSRS. M. & W. GRAZEBROOK, LIMITED, of Netherton, Dudley, have restarted a cold-blast furnace which had been idle for about six months.

THE CEYLON GOVERNMENT RAILWAYS have ordered a 20-ton Diesel shunting locomotive from Messrs. Sir W. G. Armstrong Whitworth & Company, Limited, of Newcastle-upon-Tyne.

GLASGOW CORPORATION has accepted the offer of the Quasi-Arc Electric Welding Company, Limited, for the installation of electric welding plant at Stow College, Glasgow, at a cost of £792.

A COURSE OF 24 lectures on iron and steel will be given by Mr. T. Barton Kelly at the City of London College, Ropemaker Street, Moorfields, E.C.2, on Thursdays, from 6 to 7 p.m., commencing September 27.

MESSRS. ALEXANDER HALL & COMPANY, LIMITED, Aberdeen, launched the "Bon Scot," a steel-screw harbour and sea-going tug, built for the James Dredging, Towage & Transport Company, Limited, London and Southampton.

A MASS DEMONSTRATION was held at Belle Vue, Manchester, recently, to celebrate the centenary of the founding of the Boilermakers' and Iron and Steel Shipbuilders' Society. Manchester was the birthplace of the society.

ONE OF THE LARGEST all-welded merchant vessels was recently launched at Staten Island. The steamer, the "Poughkeepsie-Socony," is a tanker of 1,242 gross tons, 260 ft. overall, 40 ft. beam, and 14 ft. depth. She aggregates 750 h.p.

IMPORTS OF NON-FERROUS ORES and scrap into Malaya during the first five months of the current year were valued at £1,333,586, as compared with £1,025,061 during the corresponding period of 1933. The relative exports were respectively £73,824 and £5,938.

JOHN LANG & SONS, LIMITED, Johnstone, have received orders from the Soviet Government for machine tools to the value of £16,500; and Messrs. Colvilles, Limited, Glasgow, have received orders from the same source for boiler plates amounting to £8,250.

THE GREEK STEAMER "Leonidas II," of 5,246 tons gross, built in 1919 by Messrs. Short Bros., of Sunderland, has arrived at Haulbowline dockyard, Queenstown, to be scrapped. The work will be undertaken by Messrs. Haulbowline Industries, Limited.

MESSRS. ROBERT STEPHENSON & COMPANY, LIMITED, Darlington, have received an order for the supply of 20 locomotives for the South African Railways. They are also to supply three locomotive boilers to the Bombay, Baroda & Central India Railway.

THE FIVE REPRESENTATIVES of South Wales and Monmouthshire on the Council of the British Iron and Steel Federation were announced at Swansea last week to be Sir John Beale, Major J. M. Bevan, Sir William Firth, Mr. Frank J. Rees, and Sir Charles Wright.

TWENTY-EIGHT ALL-STEEL LIFEBOATS are an important feature of "No. 534," the new Cunarder, to be launched next month by the Queen. Each boat weighs 16 tons fully loaded, propulsion for the first time being by Diesel engine. They accommodate 140 persons each, and cost about £1,200 each, fully equipped.

STAINLESS STEEL for cutlery, the production of which is one of Motherwell's most thriving industries, continues to be in brisk demand, and the Clyde Alloy Works, where this special steel is made, are enjoying a busy spell. The foundry is also very busy, and prospects are good for the remainder of the year.

A SURPRISE ORDER from British leather manufacturers to the Singer Sewing Machine Company, Clydebank, has restored the assembly shop to full working capacity. The earlier cancellation of a large weekly order, it was thought, would mean a curtailment of staff. This order for cobbler machines will obviate this.

THE VOICE of the new Cunarder—its whistle—will have a range of 10 miles, and yet it will not disturb the passengers on it. Instead of a piercing whistle, a bass note has been chosen. The choice was made after experiments as to nerve comfort. The funnels are unique, as the three are all of different sizes in order to allow smoke to clear quickly.

ORDERS FOR THE CONSTRUCTION of three sets of marine steam reciprocating engines have been received by Messrs. Aitchinson, Blair, Limited, Whitecrook Engine Works, Clydebank. Two of the sets will be supplied complete for Colonial owners, and the other set is for a modern coaster for Glasgow owners. This is the seventh set of steam reciprocating engines which this firm has booked this year. The works have been fully employed throughout the year.

THE SPEED and power trials of the s.s. "Petworth" were run on the Firth of Forth last week. They were carried out with the ship in fully-loaded conditions. The ship was built by the Burntisland Shipbuilding Company, Limited, for Messrs. Stephenson Clarke & Associated Companies, Limited, of London. The "Petworth" has been built to the Burntisland "economy" design, the principal features of which embody hull streamlining with propeller for minimum resistance and power with correspondingly low fuel consumption. The propelling machinery has been built by Messrs. David Rowan & Company, Limited, of Glasgow, and is also to the same high specification.

THERE WAS impressive Chinese ceremonial at the christening of the "Hai Heng," launched from the yard of Messrs Barclay Curle & Company, Limited. After Mr. Quo Tai Chi, the Chinese Minister in London, had unfurled the Chinese national flag on the launching dais, the company bowed three times in its direction. Synchronising with the smashing of the customary bottle of champagne on the prow of the vessel, and after Madame Quo Tai Chi had given the vessel its name and murmured a benediction in her native tongue, crackers set alight on the launching ways spluttered into life. The launch was noteworthy in another respect. It is the first time that a Scottish shipyard has built a steamer for the China Merchants' Steam Navigation Company, and the exploding of crackers—considered efficacious in warding off evil spirits—was in accordance with an age-long Chinese custom. The "Hai Heng" is one of two vessels being built at Clydeholm shipyard for the same owners. The vessels will carry passengers and cargo. They are regarded as the nucleus of a new Chinese mercantile marine.

Personal

MR. J. E. ROBERTS, editor of the "Refractories Journal," was married on August 18 to Miss Barbara Gill.

MR. JULIAN PIGGOTT, manager of the British Steel Export Association, will represent the British steel industry on the industrial mission which the Federation of British Industries is sending to Manchukuo.

MR. CHARLES GOODCHILD, a director of Messrs. P. & W. MacLellan, Limited, engineers, Glasgow, has retired. He was the guest of the other directors at dinner in the Central Station Hotel on August 16, when he received gifts from the directors and staff.

MR. HERBERT THORN ELWELL, of Inglewood Lodge, Great Barr, has been made a member of the Commission of the Peace for the county of Stafford. Mr. Elwell is a director of Messrs. Edward Elwell, Limited, of Wednesbury Forge, Wednesbury, and is a member of the Staffordshire County Council.

Wills

JACKSON, ROBERT BURLEIGH, of Sheffield, retired steel manager	£10,542
MURRAY-PHILIPSON, H. R., chairman of the North Eastern Marine Engineering Company, Limited, and a director of the Manvers Main Collieries, Limited	£51,392
ARUNDEL, HUBERT, of Llanarmon yn Yale, Denbigh, a director of Arundel, Coulthard & Company, Limited, textile machinery manufacturers, of Stockport	£69,055

Obituary

MR. WILLIAM CLARK, of Lundin Mill, Fife, who was employed for half a century in the Durie Foundry, Leven, has died.

MR. F. W. JENNINGS, who was a director and sales manager of Messrs. Ashwell & Nesbit, Limited, died recently. Mr. Jennings had been associated with the company since 1902.

DR. THOMAS FRASER, of Messrs. Douglas Fraser & Sons, Limited, Westbank Foundry, Arbroath, died suddenly recently. Dr. Fraser retired from active business some years ago. He was 85 years of age.

MR. FRANK WILLIAM DAVIS, a director and chief engineer of the Cleveland Bridge & Engineering Company, Limited, died at his home in Darlington recently. He had been associated with the firm for 45 years.

THE DEATH OCCURRED, after a brief illness, of Mr. Arthur Rennie, whose home was at Kilnside, Falkirk. The deceased was for more than twenty years works manager to the Camelon Iron Company. He was a shrewd and capable business man, and possessed a thorough practical knowledge of the various processes of the manufacture of light castings. Mr. Rennie served the firm from his early youth, becoming assistant manager to the late Mr. Callander, and on the death of Mr. Callander he assumed the position of works manager. Mr. Rennie was prominently identified with the Institution of British Foundrymen, and took a leading part in the formation of the Falkirk Branch of the Institute, and for some time acted as its secretary.

MR. CHARLES JOHN GRAHAM MACGUCKIN, who died in London on August 17 at the age of 50, was formerly well known in engineering circles on the Tyne and Clyde. Since 1930 he had been associated with the Bar, but had been ill since January, 1933. Mr. MacGuckin started his career at the Elswick Works of Messrs. Armstrong Whitworth & Company in 1900, serving his time as an apprentice. Eventually he became general manager of the firm, after which he managed the Openshaw Works at Manchester. He then left Manchester to take up an appointment as managing director of Messrs. William Beardmore & Company, Limited, Parkhead Steelworks, Glasgow. While at the Elswick Works of Armstrong Whitworth during the war he effected great improvements in the quality of armour-piercing shells.

Contracts Open

Beal, August 31.—Furnishing and laying about 3,000 yds. 3-in. spun-iron water mains, with valves, etc., for the Pontefract Rural District Council. Mr. J. E. White, Tanshelf House, Pontefract. (Fee £1, returnable.)

Chile.—Statue over 12 metres in height, which it is proposed to erect to commemorate the peace and friendship existing between Chile and Peru, for the Chilean Government. The Department of Overseas Trade. (Reference G.Y. 14,201.)

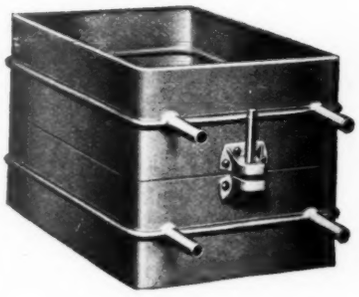
Leeds, September 10.—Cement-lined socket and spigot spun-iron pipes, for the Waterworks Committee. The Town Clerk's Committee Department, Room 57, Civic Hall, Leeds, 1.

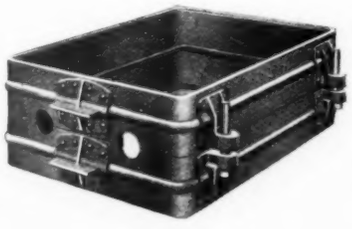
Lorton, August 30.—Supply and laying of about 2,600 yds. 3 in. dia. concrete-lined spun-iron pipes, 400 yds. 2 in. cast-iron pipes, and 460 yds. 1½ in. dia. wrought-iron pipes, with valves, etc., for the Cockermouth Rural District Council. Mr. A. E. Simpson, engineer to the Council.

Southam, September 3.—Providing and laying about 1,570 yds. 3 in. spun iron and steel water mains, for the Winchcomb Rural District Council. Mr. H. W. Stephens, clerk to the Rural District Council, High Street, Winchcomb, Glos. (Fee £1 1s., returnable.)

The Department of Overseas Trade announce that they have re-appointed Dorland Advertising, Limited, as the official advertising agents for the 1935 British Industries Fair, which opens in London on February 18 and Birmingham on May 20. It will be remembered that, as regards Birmingham, the new title is "B.I.F. Engineering and Hardware." Mr. Sydney Walton will again direct the news service of both sections, and the news for them will be handled by Mr. Robert Williamson from 10, Adam Street, Adelphi, W.C.2.

Sterling





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Raw Material Markets

British manufacturers of iron and steel continue to be satisfactorily employed, and, with a strong buying movement expected to set in within the next week or two, prospects for the autumn are distinctly encouraging. There is a steady demand for pig-iron at home; there are also indications of a slight revival in the export trade in iron. An interesting feature has been the shipment of over 1,000 tons of iron from the Tees to Australia—the first cargo sent in that direction for many years.

Pig-Iron

MIDDLESBROUGH.—Work at the foundries and steelworks in this district was stopped last week for the local holiday. A good deal of the iron output had, therefore, to be taken into stock. Any surplus that has accumulated, however, should be rapidly absorbed when the expected autumn demand materialises. The Scottish demand for Cleveland iron is expanding in a very satisfactory manner. There is no hint that any variation in foundry-iron prices is contemplated at present. The basis prices of No. 3 Cleveland G.M.B. pig-iron for home sales are 67s. 6d. per ton delivered Middlesbrough, 69s. 6d. delivered North-East Coast, 67s. 3d. delivered Falkirk and 70s. 3d. delivered Glasgow. No. 1 foundry iron is 2s. 6d. per ton more than No. 3, and No. 4 foundry and No. 4 forge are both 1s. less.

The East Coast producers of hematite are experiencing quite a satisfactory demand, being able to undercut the West Coast works by several shillings per ton in most areas. Deliveries to South Wales have now been resumed after rather a long interruption. Home sales continue to be regulated by the agreed scale of minimum prices, based on No. 1 East Coast hematite at 68s. per ton delivered Middlesbrough.

LANCASHIRE.—The amount of new business in pig-iron coming forward from this area has shown signs of expansion, but is still limited, as consumers, believing that an early increase in prices is extremely unlikely, are allowing current contracts to run their course before negotiating for replacement. The foundries are still fairly busy, and activity in this area during the remaining months of the year is expected to be up to the level of the January-June period. For delivery to users in the Lancashire zone, Derbyshire, Staffordshire, and North-East Coast brands of No. 3 pig-iron are quoted on the basis of 74s. per ton, with Northants offered at 72s. 6d., Derbyshire forge iron at 69s. to approved consumers, Scottish foundry around 82s. 6d., West Coast hematite at about 80s. 6d., and East Coast at from 75s. to 76s. per ton, according to grade.

MIDLANDS.—Activity at the foundries is now in full swing again, the light-castings makers being, as before, the most busily-engaged section. There does not appear to be, at the moment, any further expansion in the demand for iron from the general engineering and jobbing founders. The controlled prices, delivered this area, for Midland brands of iron are 67s. 6d. per ton for Northamptonshire No. 3 and 71s. for Derbyshire, Lincolnshire and Staffordshire No. 3, delivered to Birmingham and Black Country stations, and subject to a graduated rebate for large consumers. In respect to special irons for engineering trades, etc., many brands are being offered, the prices varying according to analysis and the tonnage involved. Low-phosphorus irons, including Scottish irons, are offered at from 85s. to 90s., medium-phosphorus pig from 73s. to 80s., and refined iron at from £5 10s. to £6 15s. per ton delivered this area.

SCOTLAND.—The volume of new orders for pig-iron is limited, the steelworks and light foundries having already covered their requirements up to the end of the year. There is still room for improvement as far as the heavy foundries are concerned. There is no change in the official minimum of 70s. for No. 3 Scottish foundry f.o.t. furnaces, with 2s. 6d. extra for No. 1. There is no great demand for the latter. For Cleveland iron the special prices for Scotland are unchanged at 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow for No. 3, with other English irons obtainable at slightly below these figures.

Coke

The foundry-coke market remains very firm in tone. Most consumers are covered until the end of the year, and some even as far as next spring. In the circumstances, there is little likelihood of any reductions in prices. Present quotations for delivery in the Birmingham area are as follow:—Best Durham coke, 36s. to 40s.; Welsh coke, from 37s. 6d. to 45s. per ton.

Steel

Brighter conditions have characterised the steel markets of late than for some weeks past, states the official report of the London Iron and Steel Exchange. Inquiry has been more active and merchants and consumers have shown a greater interest in the market. Consumers appear to have allowed their stocks to get very low during the holiday season, and are now preparing for the autumn demand, which it is anticipated will be on a substantial scale. Steady conditions continue to rule in the semi-finished steel department. The market has become more active of late and prices are firm in spite of a certain amount of competition from imported Continental material. In the finished-steel section there has been some increase in buying on home account. Most of the works are in a good position as regards orders in hand, and there has been an encouraging expansion in inquiry from overseas markets.

Scrap

In the Cleveland district, there has been little buying of scrap iron lately, as a consequence of the holidays, and values are therefore nominally unchanged. In the Midlands, heavy machinery metal is maintained at 55s., good heavy metal at 50s., and clean light at 47s. 6d., all delivered works. The demand for scrap iron in South Wales shows little improvement, heavy metal remaining at 45s. to 47s. 6d., with machinery grade at 49s. 6d. to 50s. 6d. A few small parcels of light cast-iron scrap have been sold at about 40s. per ton. In Scotland, heavy iron machinery scrap is slow of sale, at about 55s. to 56s., whilst ordinary cast-iron scrap is being picked up at 51s. 6d. to 52s. 6d. per ton.

Metals

Copper.—The price of standard copper recovered slightly towards the end of last week, from the very low level previously ruling, but even so the tone of the market is far from confident, as there has been little or no improvement in the consumptive demand.

"The outlook is still obscure, and the weakness of the dollar and sterling, in terms of gold, does not make the situation any clearer. It is rumoured, however, that the producers will hold a meeting in October, when it is hoped that some reasonable scheme for helping the industry will be formulated. There have been welcome signs on the Continent that demand is again reviving," report Messrs. Brandeis, Goldschmidt.

Daily market prices:—

Cash.—Thursday, £28 2s. 6d. to £28 3s. 9d.; Friday, £28 3s. 9d. to £28 5s.; Monday, £28 3s. 9d. to £28 5s.; Tuesday, £27 18s. 9d. to £28; Wednesday, £28 1s. 3d. to £28 2s. 6d.

Three Months.—Thursday, £28 8s. 9d. to £28 10s.; Friday, £28 10s. to £28 11s. 3d.; Monday, £28 11s. 3d. to £28 12s. 6d.; Tuesday, £28 5s. to £28 6s. 3d.; Wednesday, £28 7s. 6d. to £28 8s. 9d.

Tin.—Quotations for this metal have shown an uncertain tendency lately, partly as the result of the withdrawal of speculative support on the London market. Nevertheless, indications are not wanting of a slight improvement in the industrial demand for tin. The tinplate trade in this country has been quite busy lately, whilst activity at the German motor and tinplate works is being maintained at a high level. Although the tin-consuming industries in the United States are not so busy as they were, stocks have been allowed to run very low, and a fresh buying movement is expected to set in shortly. In the latter connection there have been rumours of impending discussions between the American and British Governments with reference to supplies of this metal, but they seem to have little basis.

Price fluctuations:—

Cash.—Thursday, £226 15s. to £227; Friday, £226 17s. 6d. to £227; Monday, £228 2s. 6d. to £228 5s.; Tuesday, £227 2s. 6d. to £227 5s.; Wednesday, £226 15s. to £227.

Three Months.—Thursday, £226 15s. to £227; Friday, £226 15s. to £227; Monday, £227 15s. to £227 17s. 6d.; Tuesday, £226 17s. 6d. to £227; Wednesday, £226 5s. to £226 10s.

Spelter.—The price of this metal has remained stable. Although the Continental spelter trade is still in a discouraging state, there is quite a good demand from consumers in this country. The shortage of Empire metal still prevails, and there has been a continued demand for supplies of duty-free foreign grades.

Day-to-day quotations:—

Ordinary.—Thursday, £13 15s.; Friday, £13 17s. 6d.; Monday, £13 17s. 6d.; Tuesday, £13 13s. 9d.; Wednesday, £13 13s. 9d.

Lead.—The lead market maintains its steady tone. European lead consumption is not particularly good, but is expected to improve as the autumn advances. Cable-makers in this country continue to experience increased activity. Empire lead is still quoted at a good premium on the London market.

Price fluctuations have been as follow:—

Soft Foreign (Prompt).—Thursday, £10 15s.; Friday, £10 13s. 9d.; Monday, £10 13s. 9d.; Tuesday, £10 12s. 6d.; Wednesday, £10 13s. 9d.

Company Reports

Wallsend Slipway & Engineering Company, Limited.—Ordinary interim dividend of 2½ per cent.

R. & W. Hawthorn, Leslie & Company, Limited.—Dividend of 4½ per cent., less tax, for the year ended June 30 last.

Coghlan Steel & Iron Company, Limited.—Profit, after providing for depreciation, £2,551; brought in, £1,506; preference dividend, £2,097; dividend of 2½ per cent. on the ordinary shares, £968; carried forward, £992.

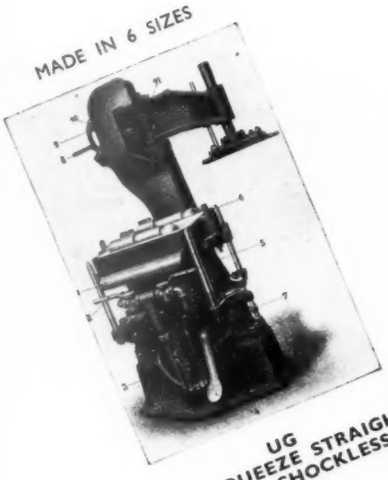
John Lysaght, Limited.—Credit balance, after providing for debenture interest and including dividends from investments and subsidiary companies, £279,892; brought in, £453,003; depreciation, £80,000; available, £652,895; dividends on preference and second preference shares, £36,000; dividend on the ordinary shares of 5 per cent., free of tax, making 8 per cent., tax free; carried forward, £456,895.

Marine Engine Work at Dalmuir

It is announced that by arrangement with National Shipbuilders' Security, Limited, Messrs. William Beardmore & Company, Limited, will cease to build main propelling machinery for ships when their present contracts at Dalmuir have been completed towards the end of next year. An official statement points out that the arrangement does not in any way affect the other industries carried on in the company's establishment at Dalmuir, which include the manufacture of high-speed Diesel engines, Bauer Wach exhaust turbines, Vulcan clutches, Caprotti valve gear for locomotive and marine purposes, and other engineering specialties. The arrangement accords with the lines of future policy of the company indicated by the chairman, Mr. H. A. Reincke, in his speech at the last annual meeting. Experience had shown, Mr. Reincke said, that the future of the company mainly rested in Parkhead, and having recognised that fact it was their duty to remove from their path all obstacles which might frustrate their efforts to consolidate the improving position there. To that end, Mr. Reincke said, it was necessary that each department should depend on its own earning power and its own command of finance, and if that was not possible it should cease to operate. No other departments must be allowed to be a drain upon Parkhead.

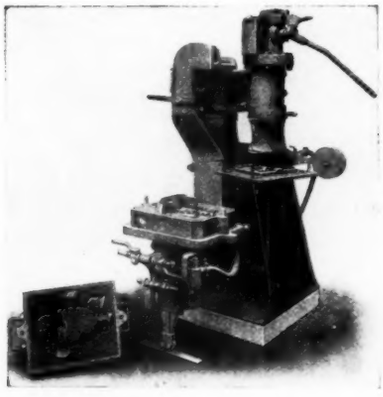
MOULDING MACHINES THERE IS A ZIMMERMANN FOR EVERY JOB

MADE IN 6 SIZES



UG
JOLT-SQUEEZE STRAIGHT DRAW. SHOCKLESS

MADE IN 4 SIZES



PW
JOLT-SQUEEZE TURNOVER SHOCKLESS

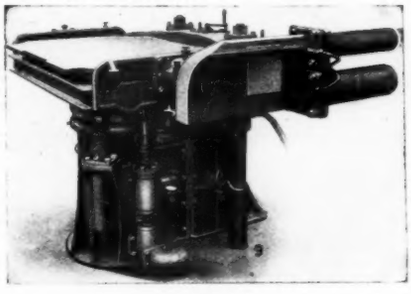
MADE IN 12 SIZES

SR
PLAIN JOLTER SHOCKLESS

MADE IN 6 SIZES

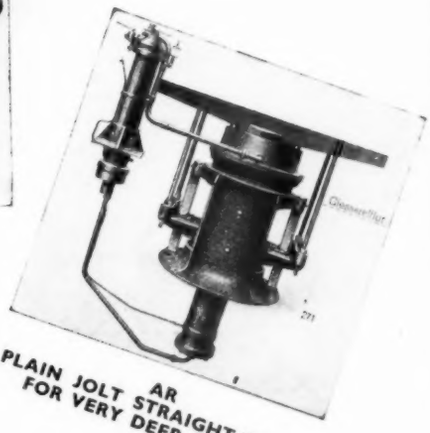
RPW
JOLT-SQUEEZE TURNOVER SHOCKLESS

MADE IN 6 SIZES



SRF
PLAIN JOLT TURNOVER SHOCKLESS

SPEED AND ACCURACY



AR
PLAIN JOLT STRAIGHT DRAW FOR VERY DEEP MOULDS

A SOUND INVESTMENT

BE PREPARED TO MEET THE GROWING SCARCITY OF GOOD MOULDERS BY INSTALLING A **ZIMMERMANN**

Take the First Step TO-DAY—and Send us Your Enquiries

ZIMMERMANN MACHINES, 37/38, GOLDEN SQUARE, LONDON, W.1 GERRARD 1051

XUM

RAW MATERIALS—PRICE LIST

(Wednesday, August 29, 1934)

COPPER

	£	s.	d.
Standard cash	28	1	3
Three months	28	7	6
Electrolytic	31	0	0
Tough	29	15	0
Best selected	30	5	0
Sheets	58	0	0
India	40	15	0
Wire bars	31	10	0
Ingot bars	31	10	0
H.C. wire rods	34	5	0
Off. av. cash, July	29	15	0
Do., 3 mths., July	30	2	1 1/16
Do., Sttlmnt., July	29	15	0
Do., Electro, July	33	0	0
Do., B.S., July	32	13	0 2/3
Do., wire bars, July	33	4	5 5/16
Solid drawn tubes			9 1/2d.
Brazed tubes			9 1/2d.
Wire			6 1/4d.

BRASS

Solid drawn tubes	8 3/4d.
Brazed tubes	10 1/4d.
Rods, drawn	8 1/4d.
Rods, extd. or rlld.	4 1/4d.
Sheets to 10 w.g.	7d.
Wire	7 1/2d.
Rolled metal	6 1/2d.
Yellow metal rods	4 1/4d.
Do. 4 × 4 Squares	5 1/2d.
Do. 4 × 3 Sheets	5 1/4d.

TIN

	£	s.	d.
Standard cash	226	15	0
Three months	226	5	0
English	227	0	0
Bars	228	15	0
Straits	227	5	0
Australian (nom.)	—		
Eastern	228	0	0
Banca	227	15	0
Off. av. cash, July	230	9	3 9/11
Do., 3 mths., July	230	1	5 5/11
Do., Sttlmt., July	230	8	10 4/11

SPELTER

	£	s.	d.
Ordinary	13	13	9
Remelted	14	5	0
Hard	11	5	0
Electro 99.9	16	3	9
English	14	7	6
India	13	5	0
Zinc dust	17	0	0
Zinc ashes	3	0	0
Off. aver., July	13	11	7 1/11
Aver. spot, July	13	9	3 9/11

LEAD

	£	s.	d.
Soft foreign ppt.	10	13	9
Empire (nom.)	11	7	6
English	12	10	0
Off. average, July	10	18	6 5/11
Average spot, July	10	16	3

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	5	0
Do., V.M. ex whse.	21	12	6
Rods	27	10	0

ANTIMONY

	£	s.	d.
English	43 0 0 to 45	0	0
Chinese, ex-whse.	36	10	0
Crude	—		

QUICKSILVER

	£	s.	d.
Quicksilver	11 2 6 to 11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£13 0 0
75%	£18 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	5/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£16 0 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£29 15 0
4/6% car.	£23 0 0
6/8% car.	£21 12 6
8/10% car.	£21 12 6
Ferro-chrome—	
Max. 2% car.	£35 10 0
Max. 1% car.	£38 10 0
Max. 0.70% car.	£41 5 0
70%, carbon-free	10d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/- lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 5 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/2 in. × 1/4 in. to under 1 in. × 1/2 in.	3d. lb.
Do., under 1/2 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	2	13	6 to	2	15	0
Bundled shrngs.	2	5	6 to	2	7	6
Mixed iron and steel				2	8	0
Heavy cast iron	2	5	0 to	2	7	6
Good machinery	2	9	6 to	2	10	6
Cleveland—						
Heavy steel				2	10	0
Steel turnings				1	17	6
Cast-iron borings				1	7	6
Heavy forge				2	10	0
W.I. piling scrap				2	5	0
Cast-iron scrap	2	10	0 to	2	12	6
Midlands—						
Light cast-iron scrap				2	7	6
Heavy wrought iron				2	17	6
Steel turnings, f.o.r.				1	12	6
Scotland—						
Heavy steel	2	10	0 to	2	11	3
Ordinary cast iron				2	12	0
Engineers' turnings				2	0	0
Cast-iron borings				2	0	0
Wrought-iron piling				2	11	3
Heavy machinery	2	15	0 to	2	16	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	25	0	0
Brass	17	10	0
Lead (less usual draft)	9	10	0
Tea lead	7	0	0
Zinc	9	0	0
New aluminium cuttings	69	0	0
Braziery copper	22	0	0
Gunmetal	23	0	0
Hollow pewter	145	0	0
Shaped black pewter	110	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
„ at Falkirk	67/3
„ at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	68/-
Hematite M/Nos.	67/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
„ d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
„ No. 3 fdry.	71/-
Northants forge	63/6
„ fdry. No. 3	67/6
„ fdry. No. 1	70/6
Derbyshire forge	67/-
„ fdry. No. 3	71/-
„ fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
„ No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
„ fdry. No. 3	68/6
Lincs forge	64/6
„ fdry. No. 3	68/6
E.C. hematite	80/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	12	6 to	9	15	0
Nut and bolt iron	7	10	0 to	8	0	0
Hoops	10	10	0 and up.			
Marked bars (Staffs) f.o.t.			12	0	0	
Gas strip	10	10	0 and up.			
Bolts and nuts, 1/2 in. × 4 in.			14	0	0	
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	0	0 to	8	10	0
Chequer plts.			10	7	6	
Angles			8	7	6	
Tees			9	7	6	
Joists			8	15	0	
Rounds and squares, 3 in. to 5/8 in.			9	7	6	
Rounds under 3 in. to 1/8 in. (Untested)			8	12	0	
Flats—8 in. wide and over			8	12	6	
„ under 8 in. and over 5 in.			8	17	6	
Rails, heavy	8	5	0 to	8	10	0
Fishplates	12	5	0 to	12	10	0
Hoops (Staffs)			9	7	0	
Black sheets, 24g. (4-t. lots)			10	10	0	
Galv. cor. shts. („)			13	0	0	
Galv. flat shts. („)			13	10	0	
Galv. fencing wire, 8g. plain			14	10	0	
Billets, soft			5	10	0	
Billets, hard	6	17	6 to	7	2	6
Sheet bars	5	2	6 to	5	7	6
Tin bars	5	2	6 to	5	7	6

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9d.
Sheet to 10 w.g.	10d.
Wire	11 1/2d.
Rods	10d.
Tubes	13d.
Castings	11d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.76
Malleable, Valley	18.50
Grey forge, Valley	18.25
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
„ furnace	20/-
Durham foundry	20/- to 25/-
„ furnace	17/6
Midlands, foundry	—
„ furnace	—

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	18/-
„ 28×20 „	36/-
„ 20×10 „	26/-
„ 18 3/4×14 „	18/7 1/2
C.W. 20×14 „	15/9
„ 28×20 „	33/3
„ 20×10 „	22/6
„ 18 3/4×14 „	15/9

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	6	0	0 to	7	0	0
Bars-hammered, basis	16	0	0 to	16	10	0
Bars and nail-rods, rolled, basis	15	15	0 to	16	0	0
Blooms	10	0	0 to	12	0	0
Keg steel	30	0	0 to	31	0	0
Faggot steel	18	0	0 to	23	0	0
Bars and rods dead soft, st'l	10	0	0 to	12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.	
Aug. 23 ..	28	2	6	inc.	3/9
„ 24 ..	28	3	9	„	1/3
„ 27 ..	28	3	9	No change	
„ 28 ..	27	18	9	dec.	5/–
„ 29 ..	28	1	3	inc.	2/6

Electrolytic Copper

		£	s.	d.	
Aug. 23 ..	31	5	0	inc.	5/–
„ 24 ..	31	5	0	No change	
„ 27 ..	31	5	0	„ „	
„ 28 ..	31	0	0	dec.	5/–
„ 29 ..	31	0	0	No change	

Standard Tin (cash)

		£	s.	d.		
Aug. 23 ..	226	15	0	inc.	10/–
„ 24 ..	226	17	6	„	2/6
„ 27 ..	228	2	6	„	25/–
„ 28 ..	227	2	6	dec.	20/–
„ 29 ..	226	15	0	„	7/6

Tin (English ingots)

		£	s.	d.		
Aug. 23 ..	227	5	0	inc.	15/–
„ 24 ..	227	5	0	No change	
„ 27 ..	228	10	0	inc.	25/–
„ 28 ..	227	7	6	dec.	22/6
„ 29 ..	227	0	0	„	7/6

Spelter (ordinary)

		£	s.	d.		
Aug. 23 ..	13	15	0	No change	
„ 24 ..	13	17	6	inc.	2/6
„ 27 ..	13	17	6	No change	
„ 28 ..	13	13	9	dec.	3/9
„ 29 ..	13	13	9	No change	

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
Aug. 23 ..	16	5	0	No change	
„ 24 ..	16	7	6	inc.	2/6
„ 27 ..	16	3	6	dec.	1/3
„ 28 ..	16	3	9	„	2/6
„ 29 ..	16	3	9	No change	

Zinc Sheets (English)

		£	s.	d.		
Aug. 23 ..	23	5	0	No change	
„ 24 ..	23	5	0	„	„
„ 27 ..	23	5	0	„	„
„ 28 ..	23	5	0	„	„
„ 29 ..	23	5	0	„	„

Lead (English)

		£	s.	d.		
Aug. 23 ..	12	15	0	No change	
„ 24 ..	12	15	0	„	„
„ 27 ..	12	15	0	„	„
„ 28 ..	12	10	0	dec.	5/–
„ 29 ..	12	10	0	No change	

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1899	6 10 0	6 12 0	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 18 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 0	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3¾	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	8 0 6	7 7 7½
1927	7 18 9	7 17 6	7 17 6	7 14 8½	7 13 9	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 14 1½
1928	7 12 6	7 14 9	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 16 10½
1929	7 17 6	7 17 0	7 17 6	7 17 6	8 0 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 5 0	8 0 10½
1930	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1931	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1932	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1933	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1934	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	—	—	—	—	—

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